AFSWC-TDR-62-144

SWC
TDR
62-144

SNAP 2/10A GROUND TEST PROGRAM, PHASE I

by

John D. Belson
Lt USAF

TECHNICAL DOCUMENTARY REPORT NUMBER AFSWC-TDR-62-144

March 1963

Development Directorate
AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

Project No. 1831, Task No. 071

HEADQUARTERS
AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

FOREWORD

The primary purpose of this report is to describe the test equipment and data acquisition techniques which were utilized during the Phase I SNAP 10A Ground Test Program, and to document the results. All test data will be reduced and analyzed by Atomics International to complete the program.

At the time of this writing, a Phase II follow-on test program is being conducted by the Sandia Corporation. This Phase II test program not only incorporates additional safety hazards tests, but also makes provisions for re-runs of several Phase I tests which were lacking in data because of deficiencies in instrumentation.

ABSTRACT

The purpose of the SNAP 2/10A Reactor Ground Test Program was to determine the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive and impact environments.

Test engineering, data acquisition, and the preliminary test results are discussed. Atomics International will perform the final engineering analysis of the test data under USAEC contract.

PUBLICATION REVIEW

This report has been reviewed and is approved.

M. E. Sorte
M. E. SORTE
Colonel USAF
Director, Development Directorate

John J. Dishuck
JOHN J. DISHUCK
Colonel USAF
DCS/Plans & Operations

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (cont'd)

1. BACKGROUND.

On 24 October 1961, the AFSWC Nuclear Power Division (SWVP) was requested by the USAEC Canoga Park Area Office (CPAO) to conduct certain ground tests of the SNAP 2/10A reactor assembly. CPAO also requested that the Atomics International (AI) statement of work for the tests be reviewed and a cost estimate submitted by 1 November 1961.

The AFSWC Test Directorate was first consulted on conducting the proposed test program. Since their workload was critical at that time, consideration was given to using the facilities at AFMDC, Holloman AFB, for the program. A meeting was arranged between AFSWC and AFMDC on 7 November 1961, and it was decided that AFMDC would undertake the test program with AFSWC providing a detailed test plan and making the necessary documentation and funding arrangements with USAEC.

AFSWC submitted a review of the test statement of work along with a cost estimate of the program to CPAO on 20 November 1961. During the ensuing months, funding arrangements were made on a cost reimbursable basis by USAEC through AFSWC under existing agreements between those organizations. Also, a draft test plan was drawn up with inputs from AFSWC, AFMDC, CPAO, and AI, the USAEC contractor.

From 13-16 March 1962, representatives from AFSWC, AFMDC, and AI met at Holloman AFB to coordinate on the draft test plan. After several minor changes, the final Test Data and Support Document was signed on 16 March 1962 (see appendix I). Also, AFMDC accepted the obligation authority from AFSWC and immediately proceeded with test design and the necessary procurement action.

The original testing schedule for the SNAP 2/10A reactor tests called for tests to commence 20 April 1962 and for all tests to be completed by 30 June 1962. During May 1962, a revised Management Report was submitted to AFSWC which extended the testing period to 15 August 1962. A second revised Management Report was submitted to AFSWC which extended the final completion date from 15 August 1962 to 15 October 1962. These

delays and postponements resulted primarily from slips in test item delivery schedules.

The Holloman Phase of the SNAP 2/10A test program ended 10 October 1962. Final reduction of the data obtained during this program is being conducted by Atomics International. Presently, Sandia Corporation, Albuquerque, New Mexico, is conducting a follow-on program to the Holloman tests. This program should give additional information and data as to the structural behavior of the SNAP 2/10A system in missile-abort environments.

2. INTRODUCTION.*

Two basic space nuclear power systems of the SNAP (Systems for Nuclear Auxiliary Power) Program are the SNAP 2 and SNAP 10A. The reactor units for these systems are essentially the same, with the systems differing in the conversion technique used. For the purposes of this report only the SNAP 10A system is described.

The SNAP 10A unit is a small, thermoelectric-energy conversion system designed to deliver 500 watts continuous electrical power for 1 year operation in space. A reflector-controlled nuclear reactor provides the heat source; a eutectic mixture of sodium-potassium (NaK-78) is used as a coolant to transfer the heat from the core to the thermoelectric generating junctions.

The reactor occupies approximately 2 cubic feet of space and weighs about 175 pounds (figure 1). The payload shield, the integral converter, and radiator portions of the SNAP 10A system are attached to the base of the reactor, adding a cone-shaped structure with a maximum diameter of 49.5 inches at the rear end of the assembly. The total length of the SNAP 10A system is approximately 10.8 feet, and the total weight is approximately 875 pounds.

The thin-walled stainless steel reactor core vessel is approximately 9 inches in diameter by 16 inches long and contains an array of zirconium-hydride fuel rods surrounded by beryllium reflector segments inside the vessel. A large Be reflector surrounds the core vessel and contains four

* "SNAP 10A Ground Test Plan — Phase II" (Rough Draft), page 3, October 1962, Sandia Corporation, Albuquerque, New Mexico)

rotatable Be drums which have the effect of varying the outer reflector thickness to achieve start-up and control. Two of the Be drums are driven in by springs, and the other two are gear-driven by motors. Drum hold-out safety features consist of manually removable filler blocks and key lockpins, and electrically initiated explosive lockout pins. The entire outer reflector system is held in place on four compressed springs by a fusible link (brazed-joint stainless steel tension band), designed to fail and eject the entire outer reflector when subjected to heat, overpressure, or impact.

A d. c. conduction NaK pump is located on the forward end of the reactor. Stainless steel NaK lines connect the pump to the core vessel and the converter-radiator.

Atomics International, Canoga Park, California, as the AEC prime contractor, has the reactor design fabrication and initial safety responsibilities for the SNAP 10A.

3. PURPOSE OF EXPERIMENT.

The purpose of the experiment was to subject the SNAP 2/10A reactor assembly to impact, fire, explosive, and thermochemical environments to determine its structural behavior. This information is required to assess the nuclear hazard to personnel from prelaunch incidents or missile aborts. These tests were designed as part of an overall program which is to demonstrate the nuclear safety of the SNAP 2/10A power system through ground tests and a series of flight reentry tests (AFSWC-TDR-62-67, SNAP Reentry Flight Test Program).

The Phase I SNAP 2/10A Reactor Ground Test Program consisted of 14 tests, ranging from fire tests to high-velocity water-impact tests. This series of tests is discussed in this report. AFSWC served as test coordinator and administrative supervisor. The test models and instrumentation were furnished by Atomics International, with funds provided by the Atomic Energy Commission. AFMDC arranged for all physical facilities required to perform the tests and all necessary test personnel. A detailed description of the test plan and division of efforts is included as appendix I of this report.

4. THERMOCHEMICAL TESTS.

During the months of May, June, and July 1962, five thermochemical tests were performed on SNAP 2/10A reactor models at Holloman AFB. These tests were designed to simulate the fire, water, and explosion environments present during a missile abort. Instrumentation and high-speed photography were used to collect data during all five tests. Following are outlines and qualitative results of each of the above-mentioned tests.

a. Test No. 1-LOX spray.

(1) Discussion.

The reactor assembly, consisting of the reactor vessel, was mounted upright on a metal test stand (figure 2) which was located at the Holloman Horizontal Test Stand Complex. At 1300 hours, 9 May 1962, the reactor vessel was exposed to a spray of LOX for approximately 40 seconds.

(2) Instrumentation.

(a) Black-and-white still photos before and after the spray.

(b) 16mm color documentary film of the test setup and spray operations.

(c) High-speed motion picture coverage (4, 000 fps) during the initial 5 seconds of the spray operation from three cameras placed to provide complete coverage of test item behavior.

(d) 22 channels of oscillograph data were collected from 12 strain gages, 9 thermocouples, and 1 event recorder.

(3) Results.

The test item was exposed to a deluge rather than an evenly distributed spray of LOX for approximately 40 seconds. All recorders and cameras operated satisfactorily. Visual examination of the test item after the test revealed that no external damage had occurred to the core vessel. Oscillograph data were of little value since the responses from the strain gages and thermocouples were small in value. This could be explained by either the short duration of the test and/or the insensitivity of the strain gages and thermocouples that were used. Even though there was a lack of

oscillograph data, it can be concluded that the reactor will maintain its structural integrity during a LOX spray or deluge.

b. Test No. 2. - LOX-NaK interaction spray.

(1) Discussion.

The reactor assembly consisting of the reactor vessel was mounted upright in a similar manner as the test item in Test No. 1 (figure 3). At 0845 hours, 17 May 1962, explosive devices were actuated to open the NaK lines and a small amount of NaK was allowed to flow from the test item. The LOX spray, as in Test No. 1, was then initiated and continued for a short period of time.

(2) Instrumentation.

(a) Black-and-white still photos before and after the spray.

(b) 16mm color documentary film of the test set-up and spray operation.

(c) High-speed motion picture coverage (4, 000 fps) during the initial 5 seconds of the spray operation from three cameras placed to provide complete coverage of test item behavior.

(d) 11 channels of oscillograph data collected from 4 strain gages, 6 thermocouples, and 1 timing channel.

(3) Results.

Two seconds after the Squibs were fired to open the NaK lines, the LOX spray was initiated and was continued for approximately 40 seconds. Soon after the LOX spray was initiated, the NaK solidified, minimizing the initial reaction. Approximately 8 minutes after the LOX spray was terminated, the NaK began to liquify and flow from the core vessel. The NaK then reacted violently with water standing under the test stand (see figure 4).

All recorders and cameras performed satisfactorily throughout the test. Visual examination of the reactor vessel after the test showed no external damage (see figure 5). Responses on the oscillograph tape were too small to interpret. It may be concluded that a SNAP 2/10A reactor vessel with open NaK lines will maintain its structural integrity when sprayed with

LOX.

c. Test No. 3. - H_2O-NaK interaction immersion.

(1) Discussion.

The reactor assembly consisting of the reactor vessel was mounted on a test stand and immersed in a water tank which had one transparent side (figure 6). Explosive devices were then actuated which opened the NaK lines and allowed the H_2O-NaK reaction (figure 7).

(2) Instrumentation.

(a) Photo coverage from one 35mm color camera set at 2,000 frames/sec for the initial 5 seconds.

(b) One 16mm color documentary film of test setup and the actual test.

(c) Black-and-white still photos before and after the test.

(d) 11 channels of oscillograph data were collected from 4 strain gages, 6 thermocouples, and 1 timing channel.

(3) Results.

The test was conducted at 0900 hours on 6 June 1962. Soon after the Squibs on the NaK lines were fired, the reaction became so violent that one side of the water tank ruptured, allowing the water to drain from the tank (figure 8). As a result, the H_2O-NaK interaction was minimized and the test must be considered inconclusive. Visual examination of the reactor vessel showed no external damage aside from some peeling of paint (figure 9).

Under the Phase II follow-on test program presently being conducted at Sandia Corporation, a second H_2O-NaK interaction test was run because of the lack of data from the Holloman test. At the time of this writing, the final data analysis of the Sandia H_2O-NaK test was not available. Preliminary indications from both tests have shown that the SNAP 2/10A reactor vessel will retain its structural integrity when immersed with open NaK lines in water.

d. <u>Test No. 4.</u> - Fire test.

(1) Discussion.

A reactor assembly consisting of a reactor vessel and reflectors was mounted upright on a high test stand over two Sparrow boosters; three oxygen-butane burners encircled the test item (figure 10). The boosters were ignited and the resulting 4500° F flame enveloped the test item for 2.1 seconds. The "tail-off" of the boosters then ignited the oxygen-butane burners which enveloped the test item in a 1500° F flame for 15 minutes. This fire test was conducted to test reactor deformation when subjected to temperatures representative of a missile-abort fire.

(2) Instrumentation.

(a) Black-and-white still photos before and after the test.

(b) 16mm color documentary film before, during, and after the test.

(c) 25 channels of oscillograph data were collected from 12 strain gages, 12 thermocouples, and 1 timing channel.

(3) Results.

The fire test was conducted at 0810 hours on 25 July 1962. The test item was subject to a flame environment of approximately 4500°F for 2.2 seconds and, at the request of Atomics International, 1500°F for 15 minutes rather than the scheduled 5 minutes.

Upon completion of the 15-minute "cooking" period, the ga[illegible]s shut off and the test item inspected. The reflector retaining band had parted during the booster flame blast, but the reflector assembly was still in its original position; the reflector separation mechanism had been "locked" in place by the thermal expansion of two eye-bolts used for handling purposes. After the test item had cooled for approximately 20 minutes, the eye-bolts had contracted enough so that the reflector halves were released. Complete separation from the test item did not occur, since the reflector assembly was then retained by the three burner rings. Apparently, if the eye-bolts had been removed before the test, the reflector separation mechanism would have

functioned properly. The reactor vessel did not sustain any visual damage as a result of high temperatures (figure 11). Consequently, it appears from the preliminary analysis that the SNAP 2/10A core configuration would not be distorted sufficiently to prevent subsequent criticality.

e. Test No. 5. - Explosive test.

(1) Discussion.

The reactor assembly consisting of the empty reactor vessel and reflectors was suspended between two poles, 13.08 feet above the explosive charge (figure 12), and subjected to a passing blast wave of 890 psi (see appendix II for calculations). Simultaneously with the detonation of the TNT explosive, prima cord was set off to cut the reactor suspension cables. In making the test setup, caution was exercised to ensure that the test item was not subjected to the explosive fireball.

(2) Instrumentation.

(a) Black-and-white still photos of the test item before and after the test.

(b) 16mm color documentary film of the test.

(c) Fastax camera coverage of the initial shock from four 35mm cameras.

(d) 14 oscillograph channels were collected from 13 strain gages and 1 pressure transducer.

(3) Results.

The shot was detonated at 1430 hours on 23 May 1962. The reactor vessel, with the converter end presented to the explosive, survived the blast intact with only minor denting observable. The reflector assemblies separated from the reactor vessel and impacted symetrically approximately 45 feet on each side of the vessel. The four rotatable reflector drums remained locked in the "safe" position and sustained only minor structural damage (figure 13). For this particular reactor orientation with respect to the blast wave, it appears from the preliminary analysis that the SNAP 2/10A core configuration would not be distorted sufficiently to prevent any subsequent

criticality.

Since the response time of the pressure transducer was not fast enough, the transducer resulted in its destruction before an overpressure value could be recorded.* Final analysis of all other blast data will be performed by Atomics International.

5. IMPACT TESTS.

During the months of July, August, September, and October 1962, nine impact tests were performed on SNAP 2/10A reactor models at Holloman AFB. These tests were designed to simulate concrete and water impact environments which occur during a missile abort. The overall objective of the tests was to determine if the SNAP 2/10A system would maintain its structural integrity when introduced to the above environments. On-board instrumentation and high-speed photography were used to collect data during all nine tests. Following are outlines and qualitative results on each of these tests.

a. Test No. 6. - Pump-end concrete drop test.

(1) Discussion.

All of the drop tests in this series were conducted in one of the Aerobee Tower areas located at Holloman AFB. Guidelines were used to ensure that the reactor assembly impacted on the concrete target with the required attitude.

The complete SNAP 2/10A system consisting of the reactor vessel with simulated fuel rods, reflector assembly, shield, and converter structure, was impacted on the pump end of the assembly at 80 $\pm$ 10 fps (figure 14).

This test was performed to determine the structural effects and behavior of the reactor core vessel, reflector assembly, and converter

---

* The two cameras located on the southwest side of the blast jammed, resulting in no camera coverage from this side. The two cameras located on the southeast side operated satisfactorily.

section as a result of impact on the launch pad caused by missile abort on the pad.

(2) Instrumentation.

(a) Black-and-white still photos before and after the drop.

(b) 16mm color documentary film.

(c) High-speed photo coverage (6,000 fps) from two Fastax cameras.

(d) One channel of oscillograph data was collected from one accelerometer.

(3) Results.

At 1500 hours on 12 July 1962 the nose-on, low-velocity, concrete impact test was performed. Upon impact, the four rotatable reflector drums were torn loose from their support structure and the brazed tension band snapped. However, the reflector halves did not separate from the core vessel. This was due to the fact that not only was the reactor driven back into the converter structure, but also the guidelines prevented toppling of the structure after impact (figure 15).

At impact, the pump assembly was driven back into the core vessel resulting in a cracked and dished core-can lid (figure 16). Motion of the rotatable reflector drums and concurrent motion of the reflector halves were not monitored. Preliminary post-test observations have indicated that the reactor reflector assembly did not attain a configuration capable of sustaining criticality; however, further analysis will be conducted by Atomics International to substantiate this fact. All cameras and recorders performed satisfactorily.

b. <u>Test No. 7.</u> - Converter-end concrete drop test.

(1) Discussion.

The complete SNAP 2/10A system, consisting of the reactor vessel with simulated fuel rods, reflector assembly, shield, and converter structure, was impacted on the converter end of the assembly at 80 $\pm$ 10 fps (figure 17). The test procedure was the same as in Test No. 6.

(2) Instrumentation.

(a) Black-and-white still photos before and after the drop.

(b) 16mm color documentary film.

(c) High-speed photo coverage (6,000 fps) from two Fastax cameras.

(d) One channel of oscillograph data was collected from one accelerometer.

(3) Results.

At 1136 hours on 12 July 1962 the SNAP 2/10A reactor system was impacted on the converter end of the system. Upon impact, the reactor vessel, reflector assembly, and shield were forced down inside the converter-radiator structure. While inside the converter-radiator, the rotatable reflector drums were torn loose from their mountings and the reflector halves separated from the core vessel. The time sequence of the above events is not known, since time sequence instrumentation was not deemed necessary by the contractor. Also, these events were obscured from photo coverage since they occurred within the converter-radiator structure itself. As a result of the absence of data, it cannot be concluded from the preliminary investigation that the reactor reflector assembly will not attain a critical configuration when subjected to a converter-end impact.

Figure 18 shows the reactor vessel, shield, and reflector assembly after the converter-radiator structure had been lifted from the concrete pad. Examination of the reactor vessel revealed no external damage. All cameras and recorders functioned. Further analysis will be made by Atomics International.

c. Test No. 8. - Side-on concrete drop test.

(1) Discussion.

The complete SNAP 2/10A system consisting of the reactor vessel with simulated fuel rods, reflector assembly, shield, and converter-radiator structure was impacted side-on at 80 $\pm$ 10 fps (figure 19). The test procedure was the same as in Test No. 6.

(2) Instrumentation.

(a) Black-and-white still photos before and after the drop.

(b) 16mm color documentary film.

(c) High-speed photo coverage (6,000 fps) from two Fastax cameras.

(d) One channel of oscillograph data was collected from one accelerometer.

(3) Results.

At 0921 hours, 12 July 1962, the side-on concrete impact test was performed on the SNAP 2/10A reactor system. Upon impact, the brazed tension band broke, releasing the two reflector halves. Careful examination of the high-speed film of the test revealed that one of the reflector drums rotated 360° before separation from the main reflector structure. The exact positions of the rotatable reflector drums relative to one another, using a common time base, is not known.

At impact, the reactor vessel broke loose from its converter structure mountings (figure 20). Post-test examination of the reactor vessel showed no external damage. Located to the left of the reactor vessel is a portion of one of the reflector halves with rotatable control drum which had rotated to the "in" position. (See circled portion of photograph.)

Since instrumentation was not installed on the test item, sequence of events and relative positions of the reflector assembly components cannot be determined. It cannot be concluded that the reactor reflector assembly will not attain a critical configuration when subjected to side-on impact. Further testing must be performed before an accurate analysis can be made of the side-on drop test.

d. Test No. 9. - High-velocity concrete impact (nose-on).

(1) Discussion.

The reactor assembly, consisting of a reactor vessel with simulated fuel rods and reflector assembly, was stationary mounted to receive an impact on the pump end (figure 21). A concrete-faced, steel-backed target

of 24-inch minimum frontal area was impacted into the reactor assembly at 560 fps (figure 22).

(2) Instrumentation.

(a) High-speed photo coverage (6, 000 fps) of impact in color and black-and-white to describe manner in which the test item disintegrates.

(b) Event coverage during run by means of tracking cameras.

(c) 16mm color pre- and post-test motion picture coverage.

(d) 35mm color and 4 x 5 inch black-and-white stills of pre- and post-test events.

(e) Seven channels of oscillograph data were collected from five strain gages, one accelerometer, and one timing channel by hard line to high-frequency tape recorders.

(3) Results.

The first high-velocity concrete impact test was run during the morning of 15 August 1962. Upon impact, the reactor assembly completely disintegrated (figure 23). The core vessel was shattered and the simulated fuel rods were scattered for several hundred feet.

Two rows of flash bulbs with reflectors were imbedded in the ground on each side of the test item, parallel to the track (figure 21). The bulbs were to be "flashed" just before impact by means of a rail-mounted screen box and a sled-mounted knife. Since the test was run in bright sunlight, the light from the flash bulbs obscured test item disintegration.

Because of insufficient instrumentation, it is impossible to determine if a nuclear excursion could have occurred before test item breakup. Momentary rotation of the control drums to the "in-position" with the reflector halves still in place would have produced an excursion. If the dirt impact tests (at 550 fps) to be run by Sandia Corporation determine that no nuclear pulse will occur during a dirt impact, it then can be assumed that the same will hold true for a concrete impact.

No operational difficulties were encountered during the Holloman test. All cameras and recorders functioned as programed.

e. Test No. 10. - High-velocity concrete impact (nose-on).

The reactor assembly, consisting of a water-filled reactor vessel, reflector assembly, modified converter, and dummy shield, was to be stationary mounted. The target impact velocity was to be 750 $\pm$ 50 fps. However, in view of the results of Test No. 9, the contractor requested that Test No. 10 be cancelled as unnecessary.

f. General information. - Tests No. 11 through 14.

Sled-borne test items were impacted into expendable water tanks 8 feet wide, 8 feet high, and 16 feet long. The sled was restrained by a steel and concrete barrier which launched the test assembly just before water impact. In this manner, the test item was allowed to enter the water tank at least 6 feet ahead of the sled debris.

Since the water tanks used in this test series were to be expendable, they were constructed as cheaply as possible. The vertical studs were made from 2- x 6-inch pine; the lower horizontal bracing was a 4- x 8-inch oak, while the upper horizontal bracing was constructed of two 2- x 6-inch pine boards bolted together (figure 24). Since the top of the tank was left open for artificial lighting, a frame of 3- x 3-inch steel angle was placed around the top and a 3/8-inch steel rod was bolted across the top for additional strength. Three sides and the floor of the tank were 1/4-inch masonite, while the fourth side was made of 1/2-inch transparent plexiglass. Water-proof tape and 1 1/2-mil balloon plastic were used to line the tank; the plexiglass side was not covered since it was used for photography.

The steel and concrete barriers were of the approximate size as shown in figure 25. The shell was fabricated of 3/8-inch-thick steel and then filled with concrete for weight. The first barrier had a light sheet steel (0.090-inch-thick) central tube; the second barrier had a 3/8-inch-thick steel tube. This second configuration performed much better and survived three tests. For additional weight as backup to the barrier, two 5- x 5- x 3-foot concrete blocks were placed behind and to each side of the central tube. Loose dirt was then graded in place on each side of the barrier and acted as a debris

retaining bank.

The frangible sleds were constructed of horizontal 4 x 6's and vertical 6 x 6's. All four sleds were designed for a maximum payload of 900 pounds and 12 HVAR rockets.

The four test-item configurations were mounted on the frangible sleds by means of nylon webbing. This webbing not only suspended the test item at the correct height, but also restrained any rocking motion of the test item resulting from the staged or staggered firing of the HVAR rockets. The nylon webs which restrained the forward motion of the reactor model were cut by blasting caps just before impact on the sled barrier. The blasting caps were detonated by means of a track-mounted screen box.

g. Test No. 11. Side-on high-velocity water impact.

(1) Discussion.

A SNAP 2/10A configuration consisting of reactor vessel and reflector assembly was to be impacted side-on into an expendable water tank at a velocity of 550 $\pm$ 50 fps (figure 26). Six HVAR boosters were used for propulsion and were staged 2 - 2 - 2. The sled-run distance to impact was 800 feet. Firing time was approximately 1400 hours on 1 August 1962.

(2) Instrumentation.

(a) High-speed Fastax camera coverage of impact in color to describe manner in which the reactor assembly disintegrates. Four cameras were used with frame rates of 3,000, 6,000, 12,000, and 12,000 fr/sec.

(b) Still photos in black-and-white and 4 x 5 color transparencies were required before and after the test.

(c) 16mm color documentary to include installation of sled on track, installation of test item in sled, sled run and impact, and post-run activities and clean-up.

(d) Three sets of Berkeley counters for measurement of sled velocity.

(e) Screen boxes for staging of HVAR boosters placed at 80 and 360 feet from initial firing point.

(3) Results.

From an operational standpoint, the first water impact test was very successful. The test item impacted at the correct attitude with a velocity of approximately 570 fps. All photographic and instrumentation equipment functioned properly.

Upon entry into the water tank, the reflector assembly was torn from the reactor model. This separation can be seen in the Fastax films taken through the transparent side of the tank. The reactor vessel continued on through the tank, ricocheted over the dirt retaining bank on the other end, and bounced down the track about 800 feet. Except for minor denting, visual examination of the core vessel revealed no external damage (figure 27). The core vessel remained intact with the simulated fuel rods inside. Internal stresses on the grid plate, fuel rods, and core vessel cannot be determined since on-board instrumentation was not included in this test.

Since the core vessel did not break apart upon impact, it can be concluded that the SNAP 2/10A reactor will maintain a configuration capable of sustaining criticality when impacted side-on in water at velocities lower than 570 fps.

h. Test No. 12. - Head-on high-velocity water impact.

(1) Discussion.

The reactor assembly, consisting of the instrumentation can, reactor vessel, and reflector assemblies, was to be impacted head-on into an expendable water tank at a velocity of 550 $\pm$ 50 fps (figures 28, 29, 30). Six HVAR boosters were used for propulsion and were staged 2 - 2 - 2. The sled-run distance to impact was 800 feet. Firing time was approximately 1430 hours on 12 September 1962.

(2) Instrumentation.

(a) High-speed Fastax camera coverage of impact in color to describe manner in which the reactor assembly disintegrates. Four cameras were used with frame rates of 3,000, 6,000, 12,000, and 12,000 fr/sec.

(b) Still photos in black-and-white and 4 x 5 color transparencies were required before and after the test.

(c) 16mm color documentary to include installation of sled on track, installation of test item in sled, sled run and impact, and post-run activities and clean-up.

(d) Screen boxes for staging of HVAR boosters placed at 80 and 360 feet from initial firing point.

(e) High-frequency tape recorder, carried on board, to measure internally mounted strain gages.

(3) Results.

All three booster stages fired normally. Impact velocity was estimated to be 570 fps; the Berkeley counters malfunctioned during the run. The test item entered the water tank in the desired attitude. Upon entry into the tank, the simulated pump assembly, reflector assembly, and instrumentation package were torn from the reactor vessel. When the pump assembly came off, it also took the top to the reactor vessel with it. However, the fuel rods remained within the reactor vessel (figure 31).

Since the core vessel did not break apart upon impact, it can be concluded that the SNAP 2/10A reactor will maintain a configuration capable of sustaining criticality when impacted head-on in water at velocities lower than 570 fps.

No data were obtained from the internally mounted strain gages.

i. Test No. 13. - Tail-on high-velocity water impact.

(1) Discussion.

The reactor assembly, consisting of the instrumentation can, reactor vessel, and reflector assembly, was to be impacted tail-on into an expendable water tank at a velocity of 550 $\pm$ 50 fps (figures 32, 33, 34). Six HVAR boosters were used for propulsion and were staged 2 - 2 - 2. The sled-run distance to impact was 800 feet. Firing time was approximately 1400 hours on 4 October 1962.

(2) Instrumentation.

(a) High-speed Fastax camera coverage of impact in color to describe the manner in which the reactor assembly disintegrates. Four cameras were used with frame rates of 3,000, 6,000, 12,000, and 12,000 fr/sec.

(b) Still photos in black-and-white and 4 x 5 color transparencies were required before and after the test.

(c) 16mm color documentary to include installation of sled on track, installation of test item in sled, sled run and impact, and post-run activities and clean-up.

(d) Screen boxes for staging of HVAR boosters placed at 80 and 360 feet from initial firing point.

(e) High-frequency tape recorder, carried on board, to measure internally mounted strain gages.

(3) Results.

All three booster stages fired normally; Berkeley counter readings were obtained. The test item velocity at water impact was 596 fps. The test item entered the water tank in the required attitude. Upon entry into the tank, the reflector assembly tore away from the reactor vessel. While traveling through the water (exact time cannot be determined), the radiator or tail end of the reactor vessel was torn off; the fuel rods remained within the core. When the assembly impacted into the dirt retaining bank, the fuel rods were partially thrown out of the core vessel (figure 35).

Since the core vessel did not break apart upon impact, it can be concluded that the SNAP 2/10A reactor will maintain a configuration capable of sustaining criticality when impacted tail-on in water at velocities lower than 600 fps.

No data were obtained from the internally mounted strain gages. This resulted from excessive voltage which actually erased the prerecorded portion of the tape. All instrumentation and associated specifications were supplied by the contractor.

j. <u>Test No. 14.</u> - Head-on high-velocity water impact.

(1) Discussion.

The reactor assembly, consisting of the reactor vessel, reflector assembly, and shield with a portion of the radiator, was to be impacted head-on into an expendable water tank at a velocity of 750 ± 50 fps (see figures 36, 37, 38, 39). Twelve HVAR boosters were used for propulsion and were staged 2 - 4 - 6. The sled-run distance to impact was 700 feet. Firing time was approximately 1400 hours on 10 October 1962.

(2) Instrumentation.

(a) High-speed Fastax camera coverage of impact in color to describe manner in which the reactor assembly disintegrates. Four cameras were used with frame rates of 3,000, 6,000, 12,000, and 12,000 fr/sec.

(b) Still photos in black-and-white and 4 x 5 color transparencies were required before and after the test.

(c) 16mm color documentary to include installation of sled on track, installation of test item in sled, sled run and impact, and post-run activities and clean-up.

(d) Screen boxes for staging of HVAR boosters placed at 30 and 220 feet from initial firing point.

(3) Results.

The second-stage boosters did not fire; no reason for this malfunction has been positively established. Berkeley counter readings were obtained; impact velocity was only 428 fps instead of the programed 750 fps. The test item entered the water tank in the required attitude. Upon entry into the tank, the reflector assembly, the shield with its partial radiator, and the pump assembly were torn loose from the reactor vessel. As the shield came off, it took the bottom of the reactor vessel with it (figure 40). With the top of the core vessel dished-in and the bottom gone, the fuel rods still remained within the core vessel (figure 41).

Since the reactor vessel did not disintegrate upon impact, it can be concluded that the SNAP 2/10A reactor will maintain a configuration capable

of sustaining criticality when impacted head-on (with shield and partial radiator) in water at velocities less than 430 fps.

Since the desired impact velocity was not attained, this fourth water impact test must be considered inconclusive except as substantiating Test No. 12.

6. CONCLUSIONS.

Attainment of program objectives was limited by the lack of certain essential test data. Additional instrumentation would have resulted in a more meaningful program with the acquisition of more useful data.

Reference to the lack of instrumentation is made in conjunction with the explosion test, the concrete drop tests, the high-velocity concrete impact tests, and the high-velocity water impact tests. To determine if the SNAP 2/10A reactor will present a configuration capable of sustaining criticality when subjected to missile-abort environments, the relative positions of the reflector halves and rotatable control drums with reference to a common time base must be known. During the Phase I Test Program, information of this type was obtained from the high-speed Fastax motion picture films taken during the tests.

Because of the many variables involved, data obtained in this manner will not be very reliable. Had the following instrumentation been provided, data reduction would have been greatly simplified and the data would have been of a highly reliable nature:

(a) Four angular potentiometric voltage instruments, one on each rotatable control drum, rotation monitored $180^{o} \pm 2^{o}$.

(b) Electrical break-wire on reflector tension band.

(c) Recording oscillograph or magnetic tape recorder with time base for recording (a) and (b).

Sandia Corporation drafted a follow-on Phase II Ground Test Program to fill in the data gaps of the Phase I Ground Test Program (ref. SNAP 10A Ground Test Plan - Phase II Sandia Corporation, Report #SCDR 336-62, dtd 28

November 1962).

From a safety viewpoint, it is desirable that the core vessel disintegrate when impacted into water, dirt, concrete, etc. Strain gage data with common time base would be of the utmost importance if in the future it is decided that redesign is necessary. Some of the Phase I impact test items were instrumented with strain gages, but for one reason or another, little information was obtained (see text of report for specifics).

APPENDIX I

TEST PLAN

HEADQUARTERS
AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

DATA AND SUPPORT DOCUMENT

I. TASK 183107

A. USAF I. C. 2

B. AFSC Priority 38

II. TITLE OF TEST PROGRAM: "SNAP 2/10A Reactor Ground Tests"

III. MAJOR TEST OBJECTIVE: To establish nuclear safety criteria by determining the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive, and impact environments.

IV. TEST SCHEDULE:

A. Thermochemical, fire, and explosive tests: 15 April 1962 - 15 May 1962

B. Impact tests: 15 May 1962 - 30 June 1962

V. TEST COORDINATING AGENCY: Air Force Special Weapons Center, Kirtland AFB, New Mexico

VI. PARTICIPATING AGENCIES AND RESPONSIBILITIES: In accordance with agreements made between representatives of AFSWC, AFMDC, USAEC, and Atomics International the following division of responsibility is outlined:

A. Air Force Special Weapons Center will:

1. Act as the field office responsible for coordination of all USAEC-AFSC activities involved in the conduct of the test program.

2. Have the authority to require deviations in the planned program as required by changing USAF-USAEC needs.

3. Review all test procedures.

4. Provide administrative and funding arrangements between USAEC and all concerned AFSC agencies.

5. Monitor all phases of the test program to ensure timely coordination and completion.

B. Air Force Missile Development Center will:

1. Perform the tests as stipulated. (See Paragraph VII, Planning Factors.)

2. Arrange for all physical facilities required to perform the tests.

3. Provide the necessary personnel to conduct the tests.

4. Design and fabricate or arrange for the necessary mechanisms, instrumentation, and equipment to perform the tests.

5. Correlate and submit test data in a concise form to A.I. for review and disposition.

6. Submit monthly, beginning with the first time charged, total civilian man-hours, both regular and overtime, to the AFSWC project officer.

7. Submit monthly, beginning with the first charge, a list of equipment charges, both procurement and bench stock used during that period, to the AFSWC project officer.

C. USAEC, Canoga Park Area Office, will:

1. Determine general program direction and have authority to direct changes as required.

2. Arrange the necessary administrative channels for coordinating AFSC-contractor activities.

3. Arrange with Hq USAEC-DRD for the funding of the program on a reimbursable basis to AFSWC.

D. Atomics International will:

1. Provide necessary detailed test requirements and assistance to allow the design and conduct of the experiment.

2. Coordinate the design of test fixtures, sleds, and associated equipment with AFMDC to ensure that test item and test fixtures properly mate.

3. Design, manufacture, and ship to the test site completely instrumented test items.

4. Provide technical assistance in actual testing, data reduction, and correlation as required.

5. Perform analysis of test data and publish findings.

VII. PLANNING FACTORS: The following tests will be performed.

A. Thermochemical Tests

1. Test No. 1 LOX Spray

The reactor assembly consisting of the reactor vessel will be mounted upright on a suitable stand in an isolated test area. The reactor vessel shall then be exposed to an evenly distributed spray of LOX for 30-45 seconds.

Data shall be collected as follows:

a. Black and white still photos before and after the spray.

b. Sixteen mm color documentary film of the set-up and spray shall be provided.

c. High speed motion picture coverage (4000 fps) shall be provided for the initial five seconds of the spray operation from three cameras placed to provide complete coverage of test item behavior.

d. Twenty-two channels of oscillograph data will be collected from twelve strain gages and nine thermocouples, and one event recorder.

2. Test No. 2 LOX-NAK Interaction Spray

The reactor assembly consisting of the reactor vessel shall be mounted upright on a suitable stand.

Explosive devices will be actuated to allow a small amount of NAK to flow out. The LOX spray as in Test No. 1 shall be then initiated and continued for fifteen seconds.

Data shall be collected as follows:

a. Photo coverage as in Test No. 1

b. Eleven channels of oscillograph data will be collected from four strain gages, six thermocouples, and one timing channel.

3. Test No. 3 H_2O-NAK Interaction Immersion

The reactor assembly consisting of the reactor vessel shall be mounted on a suitable stand and immersed in a water tank with at least one transparent side. Explosive or mechanical devices will then be actuated to allow the H_2O-NAK reaction.

Data shall be collected as follows:

a. Photo coverage shall be provided from one 35 mm, color camera set at 2000 fr/sec. for the initial five seconds.

b. One 16mm, color documentary film as in Test No. 1

c. Eleven channels of oscillograph data will be collected from four strain gages, six thermocouples, and one timing channel.

4. Test No. 4 Fire Test

The reactor assembly consisting of a reactor vessel and reflectors shall be mounted upright on a suitable stand. The assembly shall then be enveloped by a flame of 3-5000°F for a duration of 2-5 seconds and 1500°F for five minutes.

Data shall be collected as follows:

a. B&W stills before and after test.

b. Sixteen mm color documentary.

c. Twenty-five channels of oscillograph data shall be collected from twelve strain gages, twelve thermocouples, and one timing channel.

5. Test No. 5 Explosive Tests

The reactor assembly consisting of the empty reactor vessel and reflectors shall be mounted on a suitable stand subjected to a passing blast wave of 900-1100 psi. Caution should be exercised to ensure this condition is achieved without subjecting the test item to the explosive fireball.

Data shall be collected as follows:

a. B&W stills of test item before and after tests.

b. Sixteen mm color documentary.

c. Fastax coverage of initial shock from four 35mm cameras (shutter speed to be determined).

d. Fourteen oscillograph channels shall be collected from thirteen strain gages and one pressure transducer. (may be deleted at A.I. option)

e. Cursory examination and collection of fragments after blast.

f. A simplified map showing locations of major reactor

fragments will be prepared.

B. Impact Tests

1. Tests No. 6, 7, and 8 will be Drop Tests

The complete APU system consisting of the empty reactor vessel, reflectors, shield, and converter structure shall be subjected to the following concrete impacts:

a. Impact on pump end of assembly at 80 ± 10 fps.

b. Impact on converter end of assembly at 80 ± 10 fps

c. Impact on side of assembly at 80 ± 10 fps

d. Data shall be collected as follows:

(1) B&W stills before and after each drop.

(2) Sixteen mm color documentary.

(3) High speed Fastax (6000 fps) from two cameras.

(4) One channel of oscillograph data shall be collected from one accelerometer.

2. Test No. 9 High Velocity Concrete Impact

The reactor assembly, consisting of the reactor vessel and reflectors shall be stationary mounted to receive an impact on the pump end. A concrete faced steel backed target of 24" minimum frontal area shall be impacted into the reactor assembly at 550 ± 50 fps.

Data shall be collected as follows:

a. Photography

(1) Engineering

(a) High speed coverage (6000 fps) of impact in color and B&W to describe manner in which test assembly disintegrates.

(b) Event coverage during run by means of tracking cameras.

(c) Sled motion description from time interval meters. Measurement accuracy - velocity ± 5 fps.

(2) Documentary

(a) Motion picture 16mm color.

1 Pre and post run coverage.

2 Tracking on selected sled runs.

(b) Stills, 35mm color and 4" x 5" B&W of pre and post run events.

b. Instrumentation: Record six data channels and one timing channel (five strain gages, one accelerometer) by hard line to high frequency tape recorders.

3. Test No. 10 High Velocity Concrete Impact

Identical to No. 9 except converter is modified and dummy shield is added. Target impact velocity 750 ± 50 ft/sec. Same support requirements.

4. Tests No. 11 through 14

a. Sled-borne test assemblies will impact a water target beyond the north end of the track. The sled will be restrained by suitable arresting devices to launch the test assembly just prior to impact and allow the test assembly to enter at least six feet ahead of the sled.

b. Target: An expendable water tank eight feet wide, eight feet high, and sixteen feet long will arrest the test assembly. The tank will be fabricated in the least expensive manner possible. The top will be open and one side will be fabricated of a transparent material. An attempt will be made to prevent impact damage to the reactor beyond the tank by grading loose sand in place.

c. Profiles:

Payload

Run	Weight	Configuration	V-Impact	g Max
11	300#	Reactor vessel and reflectors	550 ± 50	20 g
12	300#	"	550 ± 50	20 g
13	300#	"	550 ± 50	20 g
14	900#	" plus shield	750 ± 50	20 g

d. Photography:

(1) Engineering

(a) High speed coverage (6000 f/ps) of impact in color and B&W to describe manner in which test assembly disintegrates.

(b) Event coverage during the run by means of tracking cameras.

(c) Sled motion description from time interval meters data. Measurement accuracy - velocity + 5 fps, acceleration ± 4 g.

(2) Documentary: Same as for Tests No. 9 and 10.

e. Reporting Requirements:

(1) Photography

(a) Documentary

1. Furnish one original 16mm color motion picture describing test preparations and tests.

2. Furnish 35mm color slides and 8" x 10" B&W photographs of test events.

(b) Engineering

1. Furnish selected high speed motion picture camera coverage of the tests.

2. Print selected frames of high speed camera coverage.

(2) Instrumentation

(a) Provide one oscillograph record or high speed tape recorder together with scale factors of all data channels specified for each test.

(b) Provide data reduction reports describing sled motion.

VIII. LOGISTICS AND ADMINISTRATIVE MATTERS:

A. A possibility exists that certain of the test items may be classified. This determination will be made by USAEC, Canoga Park Area Office, and security requirements will be forwarded to AFSWC prior to shipping of test items.

B. Facilities to be provided by AFMDC

1. AFMDC will provide field shop service during run preparations.

2. Office and storage space will be available to Atomics

International in Building 1179, not to exceed 800 sq ft.

3. Track or test site for each test specified.

4. A tower drop facility for three drop tests.

C. Equipment:

1. AFMDC will furnish:

a. Oscillograph and high frequency tape recording equipment.

b. Six sleds to support the six specified track tests.

c. Four water tank targets.

d. Leads from Atomics International junction boxes to recorders.

2. Atomics International will furnish:

a. All test assemblies with end instruments installed.

b. Leads from end instruments to suitable junction boxes.

D. Engineering Services:

1. AFMDC will furnish:

a. One project engineer for sled and lab tests.

b. Sled support service including maintenance handling and operation.

c. Operation and handling service for all lab tests.

d. Engineering design of test vehicles, targets, and la' support equipment.

e. Description of sled motion from time interval meters.

f. Photographic services specified for individual tests.

2. Atomics International will furnish one field test engineer to provide technical advice and assistance during the test planning and operational phase of the test.

E. Materiel:

1. AFMDC will furnish:

a. Chemicals (excepting NAK) and explosives specified for each test.

b. Boosters required for six sled tests. Surplus boosters will be used where possible. Purchase boosters will be funded by USAEC through AFSWC.

c. Expendables, including recording paper, shop material, and instrumentation field wiring.

2. Atomics International will furnish NAK as required for the tests.

F. Personnel: AFMDC will furnish manpower required to support this program.

G. Funds: The entire program will be funded on a cost reimbursable basis by USAEC through AFSWC under existing agreements between these organizations.

H. Test Personnel: Capt D.C. Cole, AFMDC

Lt M.H. Bradley, AFSWC

Mr G.F. O'Brien, Atomics International

IX. COORDINATION SIGNATURES:

AGENCY	NAME	DATE
AFSWC	s /Mitchell H. Bradley	16 March 1962
AFMDC	s /Donald C. Cole	16 March 1962
Atomics International	s /George O'Brien	16 March 1962

APPENDIX II

CALCULATIONS FOR EXPLOSION OVERPRESSURE TEST

Appendix II

EXPLOSION TEST CALCULATIONS

Explosion calculations were based on an equation of Stoner and Bleakney found in the Journal of Applied Physics, Volume 19, page 670. For 1/2 pound rectangular blocks of TNT — Corps of Engineers Demolition Blocks — they found that the relationship between the overpressure and the distance from the charge could be expressed in the following form:

$$\pi = \frac{13.50}{Z} - \frac{769.9}{Z^2} + \frac{36,280}{Z^3}$$

$$Z = \frac{R}{(\rho\tau)^{1/3}}$$

Where R = distance from charge

π = overpressure

τ = volume of charge

ρ = specific gravity

Using 512 1/2-pound rectangular blocks of TNT, 3 1/2 x 1 3/4 x 1 3/4 inches, arranged in a compact stack eight blocks high (14 inches), eight blocks wide (28 inches), and eight blocks deep (14 inches), an overpressure of 895 psi was calculated. The following values for ρ , τ , and R were used:

ρ = 1.29

τ = 3.48 cu ft

R = 13.08 ft

$\therefore$ Z = 7.94

The Stoner and Bleakney equation is valid for values of Z ranging from 18

to 110. Since the value of Z used in the explosion test was 8, an error of $\pm 10\%$ could be possible. This in turn would give an overpressure range of 800 to 1,000 psi.

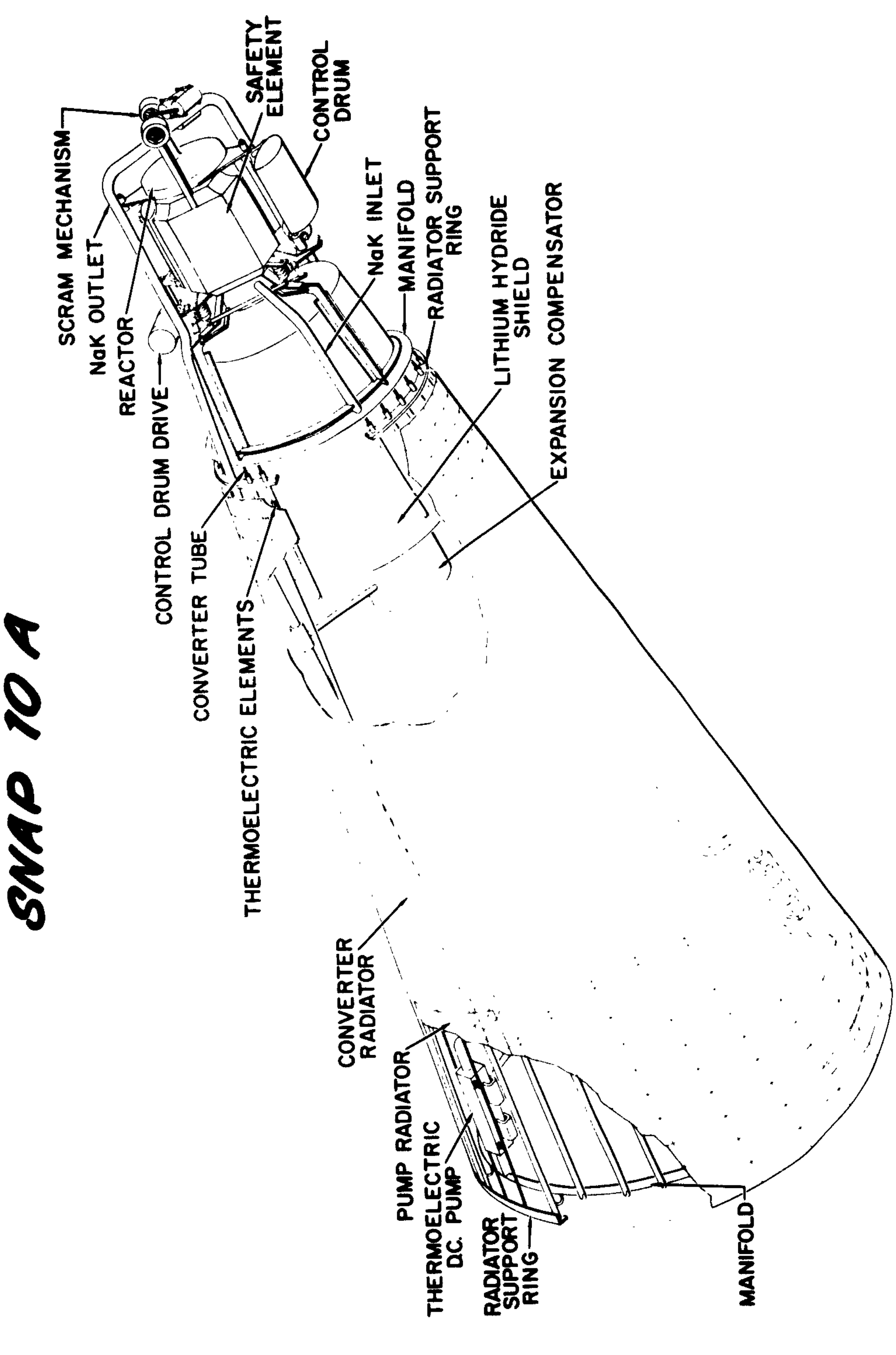

Figure 1. SNAP 2/10A Reactor assembly

Figure 2. LOX Spray test setup

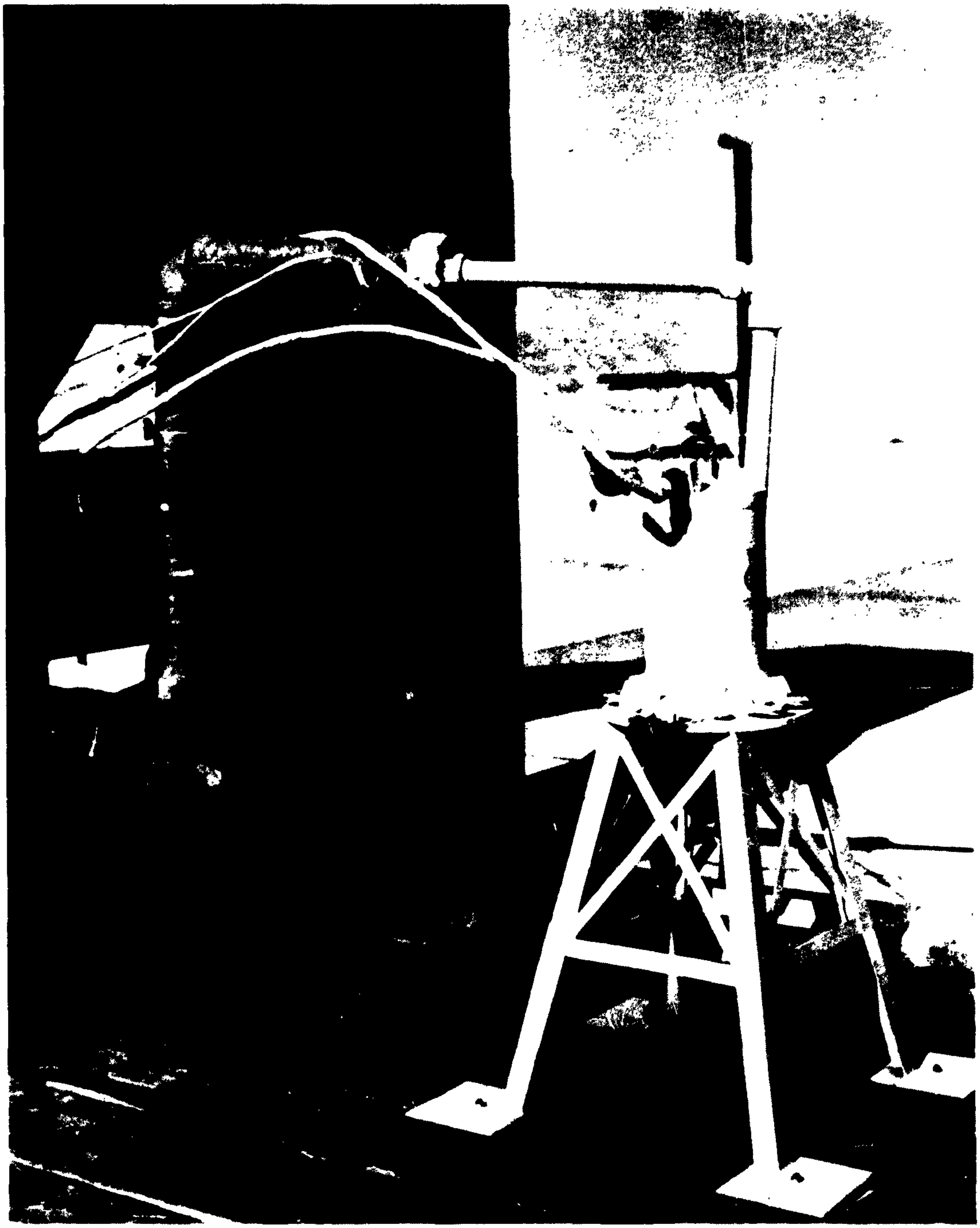

Figure 3. LOX-NaK test setup

Figure 4. LOX-NaK test

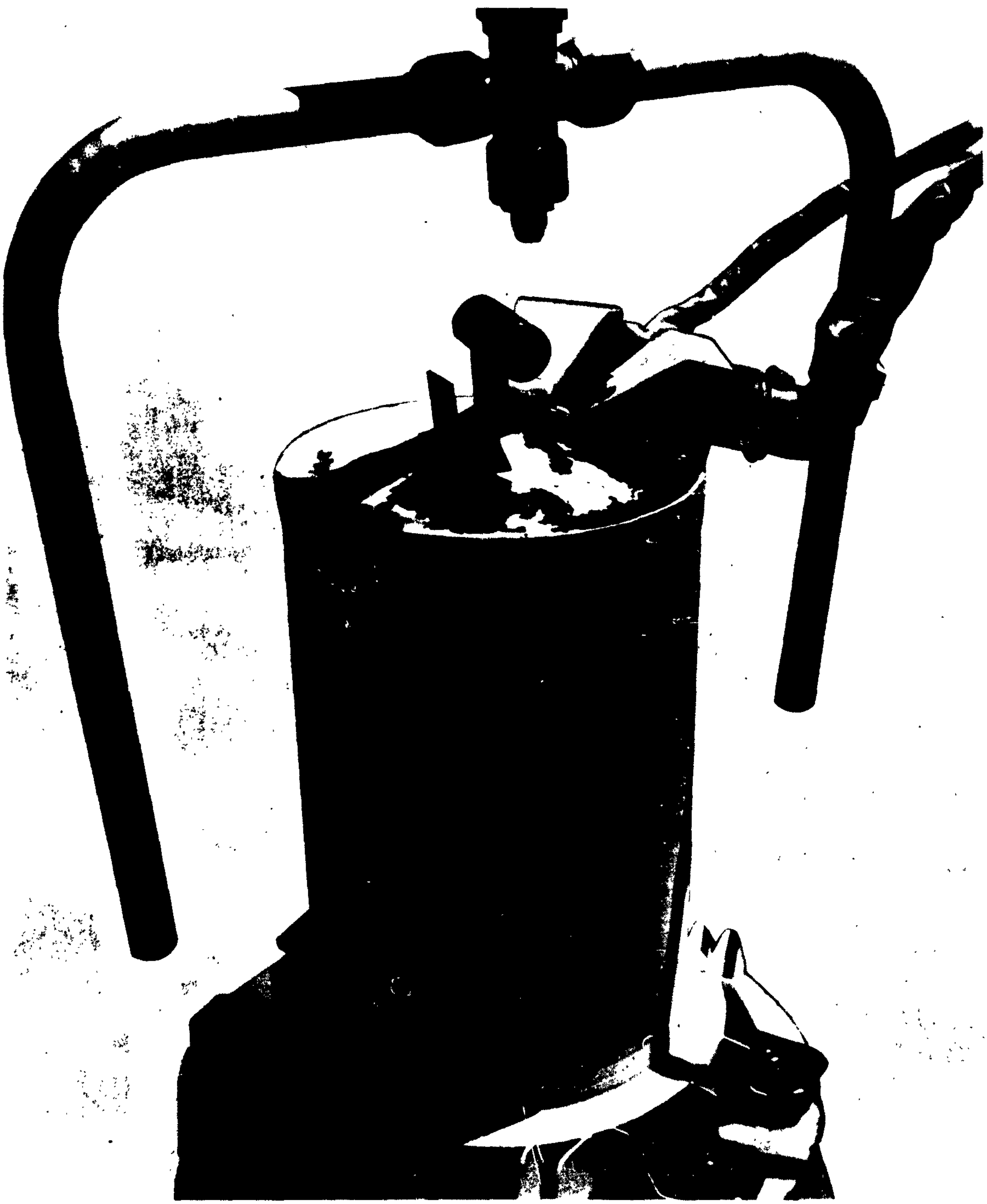

Figure 5. Reactor vessel -- post test

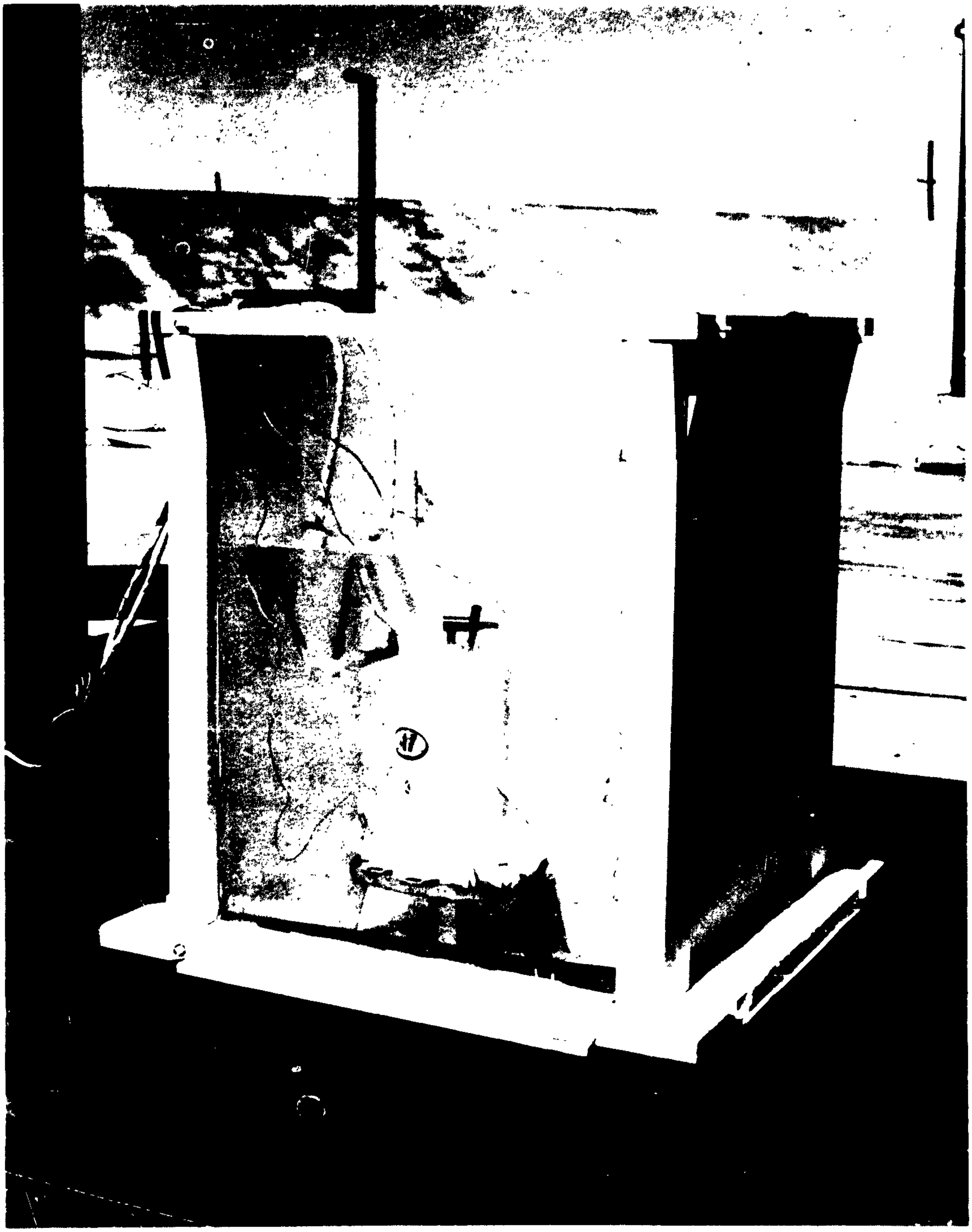

Figure 6. H_2O-NaK Immersion test setup

Figure 7. H_2O- NaK test

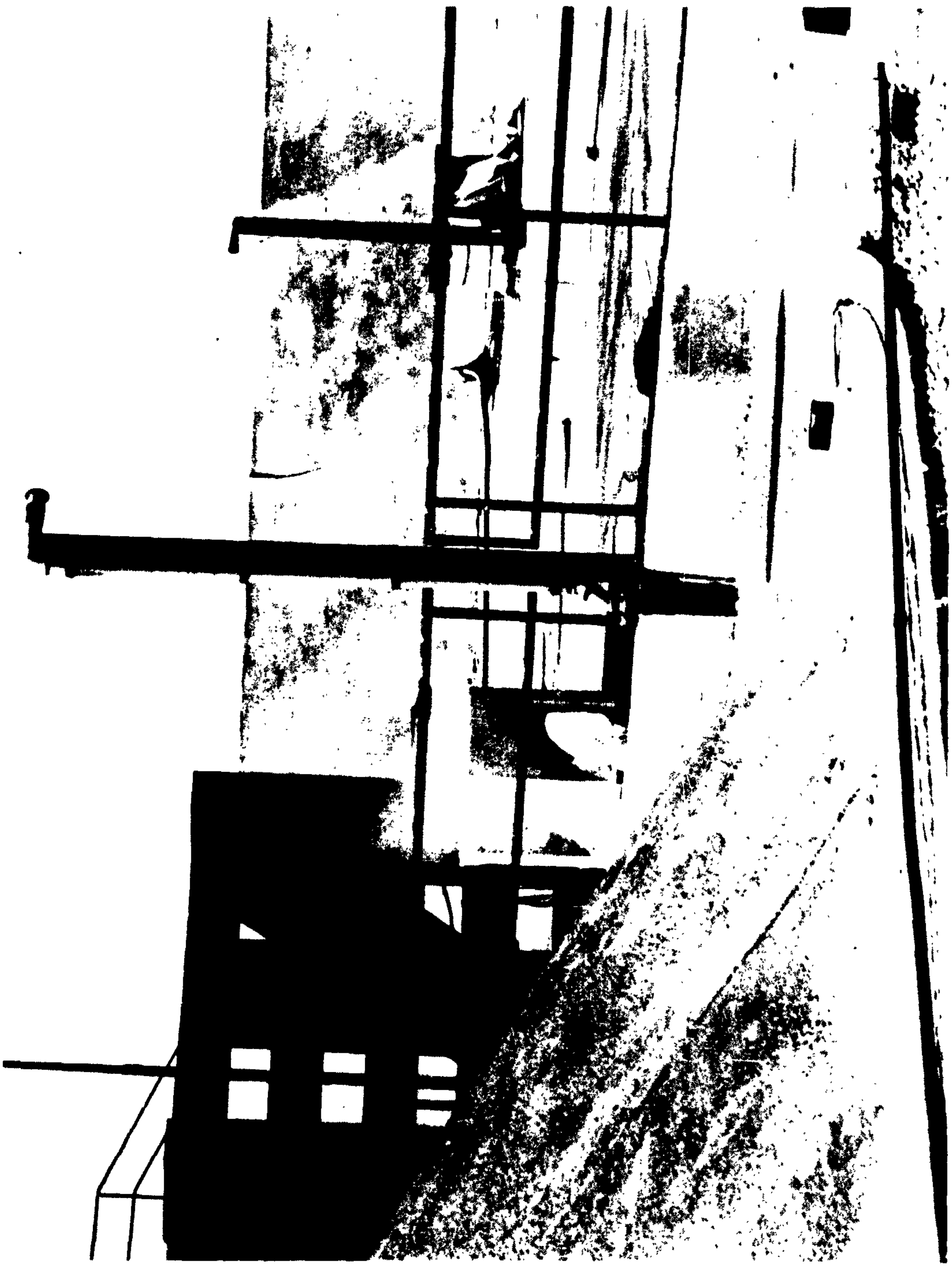

Figure 8. Water tank -- post test

Figure 9. Reactor vessel -- post test

Figure 10. Fire test setup

Figure 11. Reactor assembly -- post test

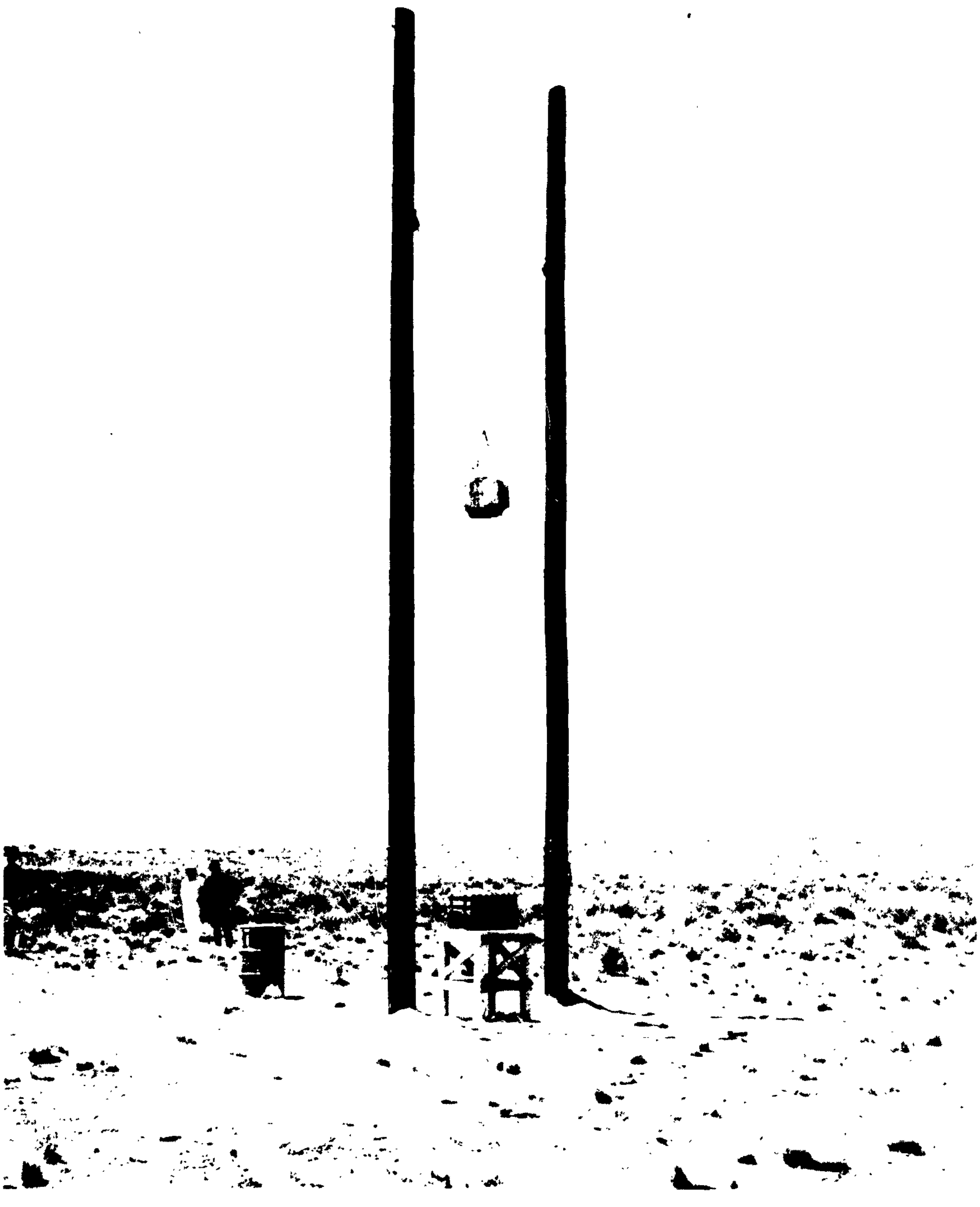

Figure 12. Explosion test setup

Figure 13. Reactor vessel -- post test

Figure 14. Low-velocity concrete impact: nose-on

Figure 15. Reactor system -- post test

Figure 16. Reactor vessel -- post test

Figure 17. Low-velocity concrete impact: tail-on

Figure 18. Reactor vessel -- post test

gure 19. Low-velocity concrete impact: side-on

Figure 20. Reactor vessel -- post test. Circle shows reflector half with control drum.

Figure 21. High-velocity concrete impact test item

Figure 22. Concrete impact test sled

Figure 23. Reactor vessel -- post test

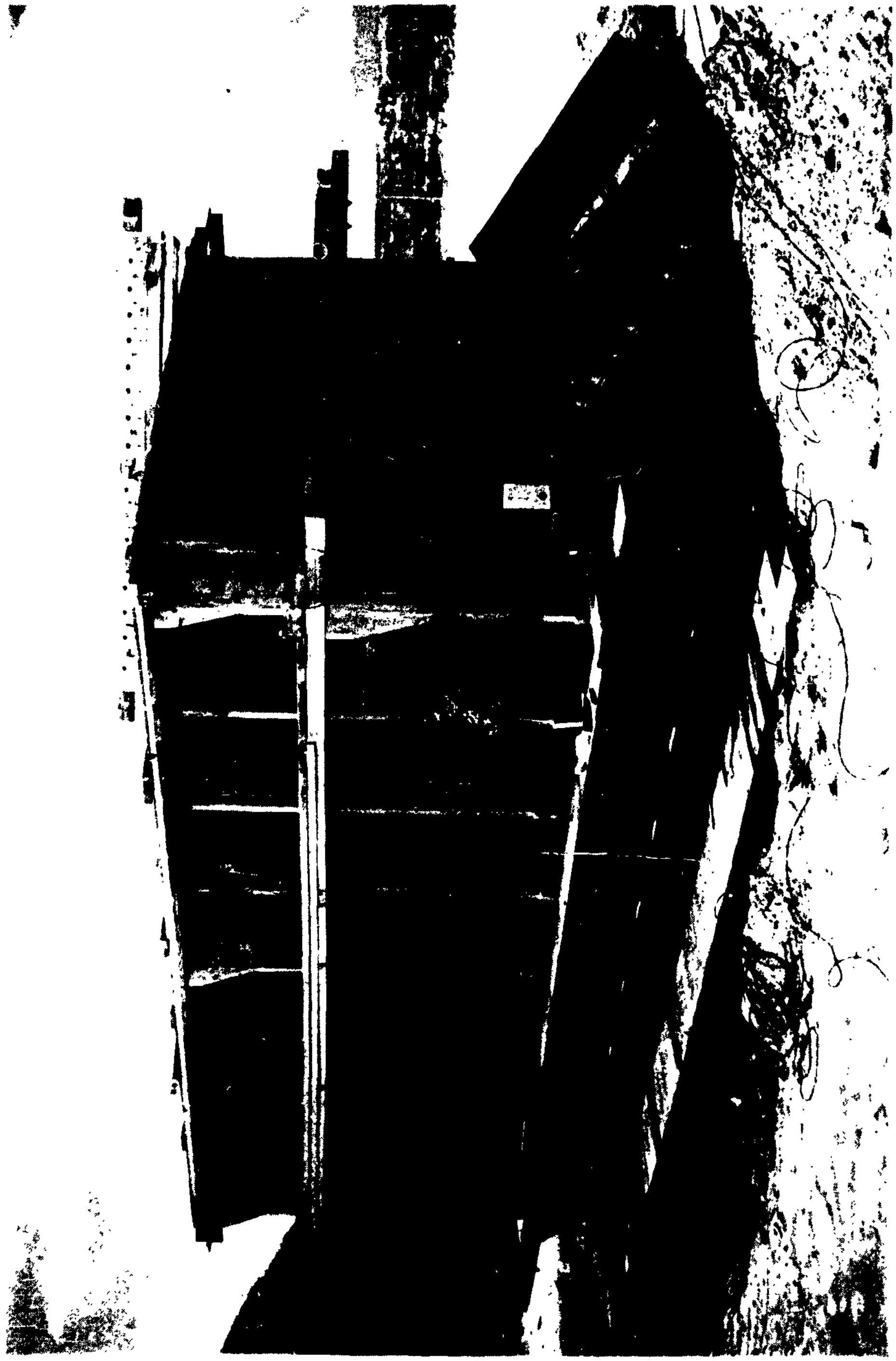

Figure 24. Frangible water tank

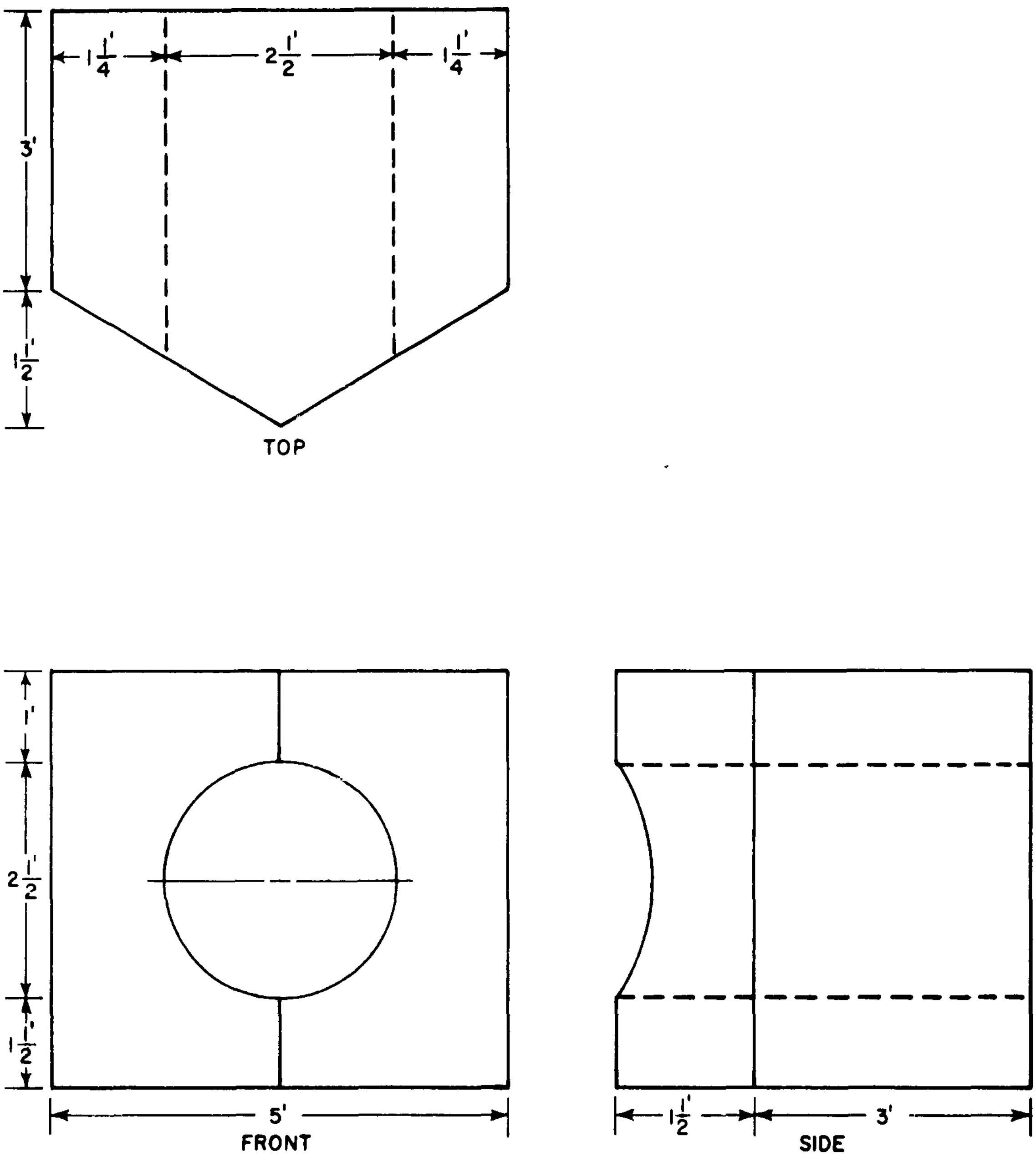

Figure 25. Three-view drawing of concrete "Sled-Splitter"

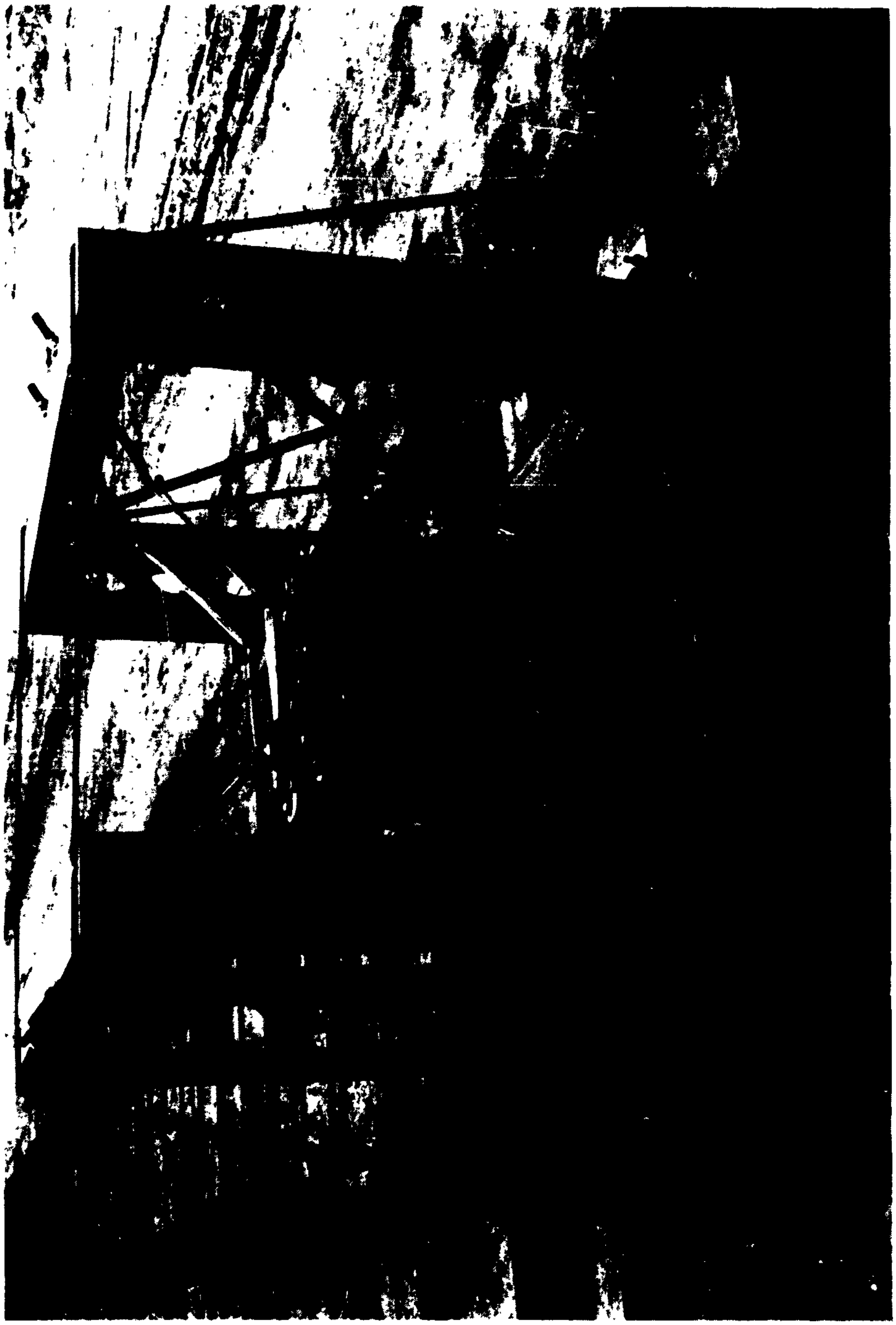

Figure 26. Sled-mounted test item -- first water impact test

Figure 27. Reactor vessel -- post test

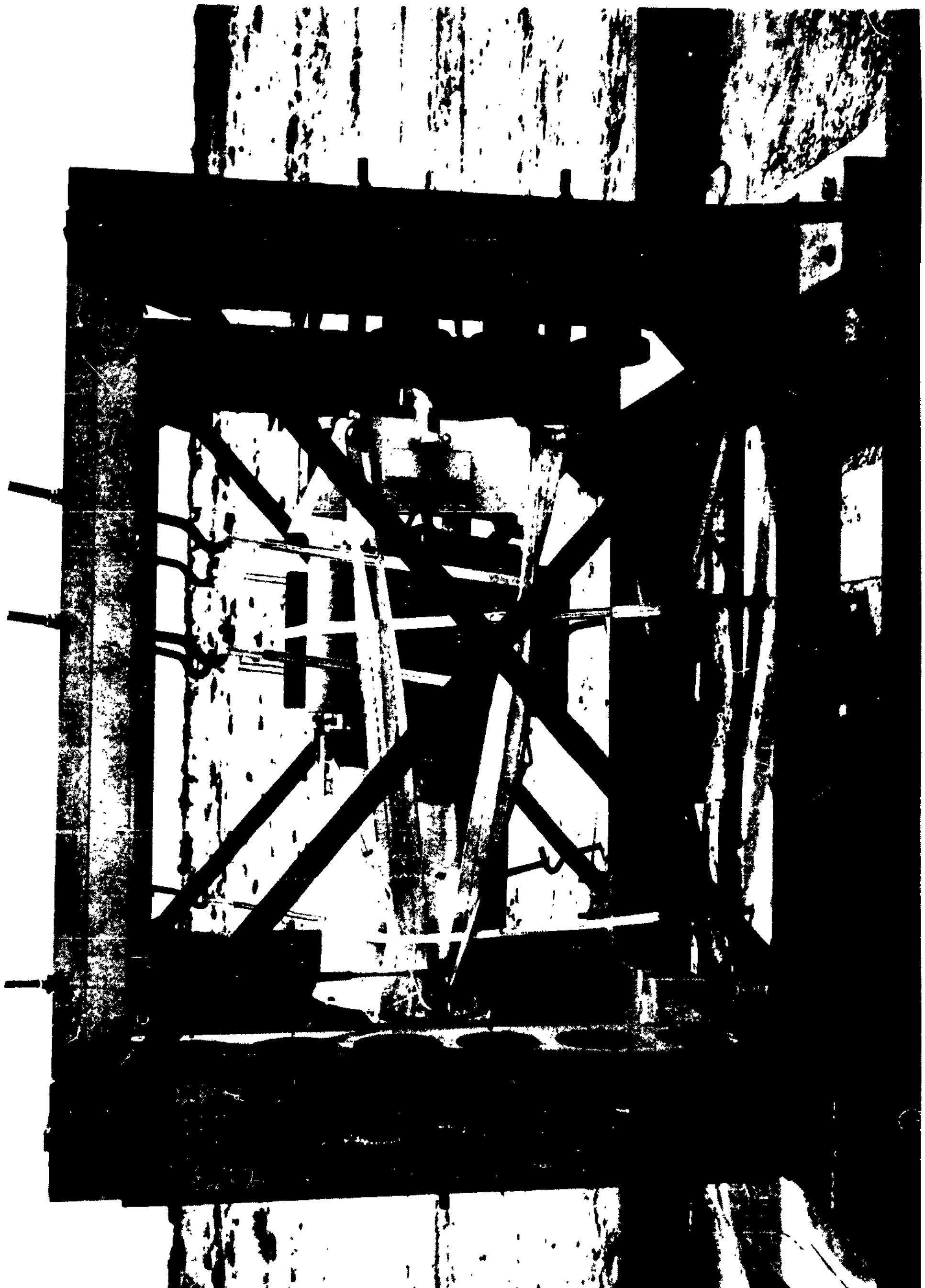

Figure 28. Sled-mounted test item -- second water impact test

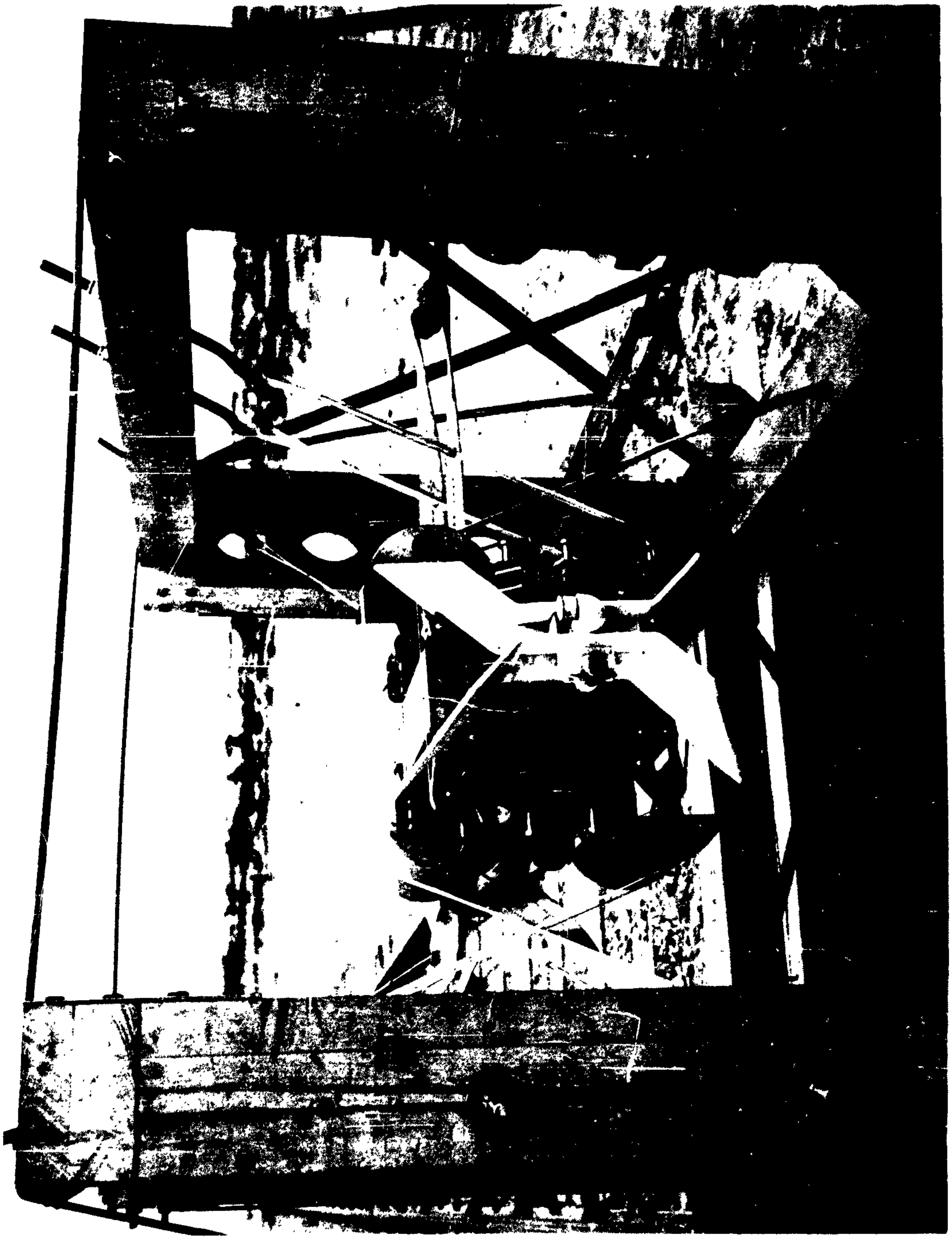

Figure 29. Sled-mounted test item -- second water impact test

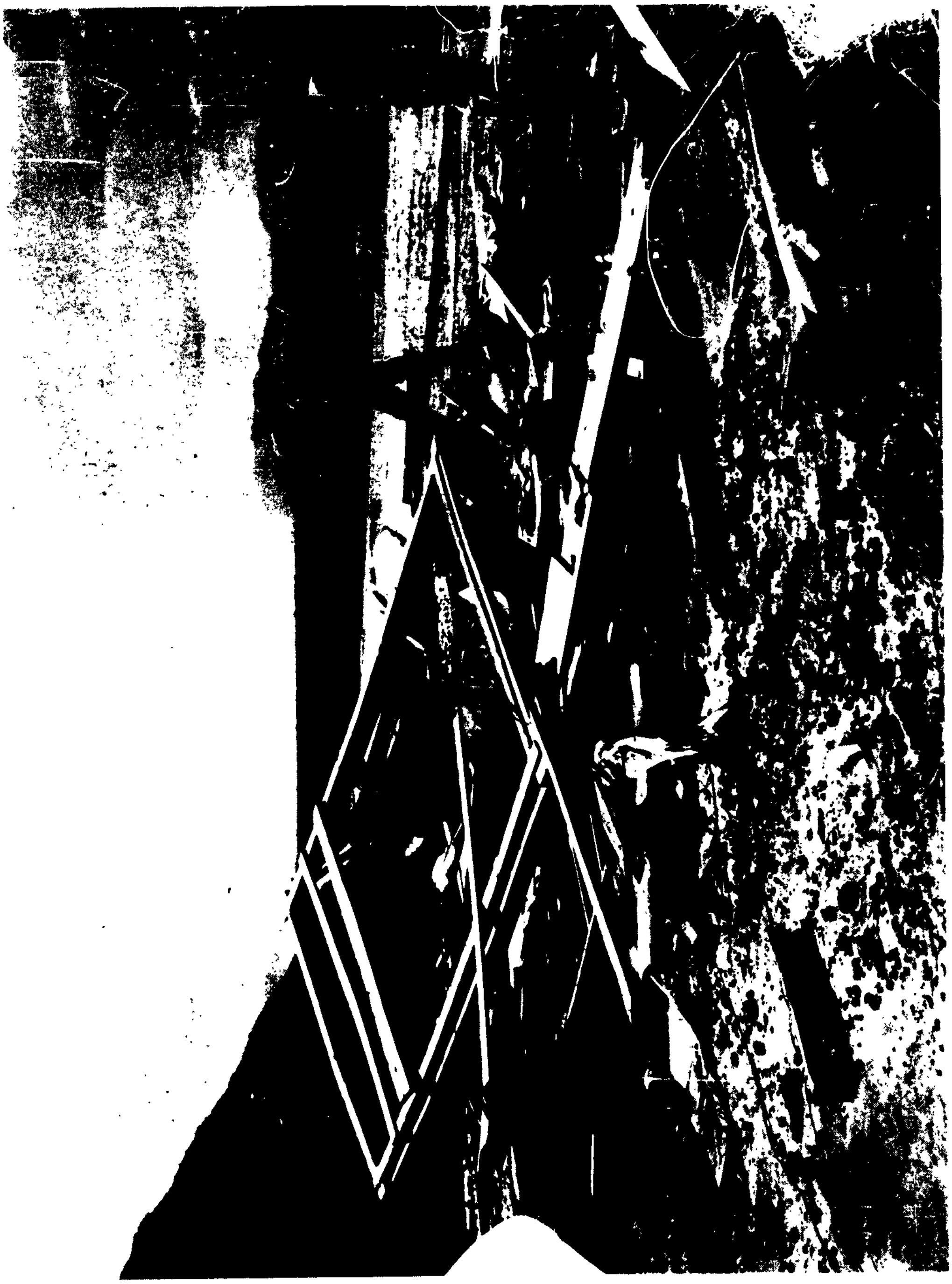

Figure 30. Frangible water tank -- post test

Figure 31. Reactor vessel -- post test

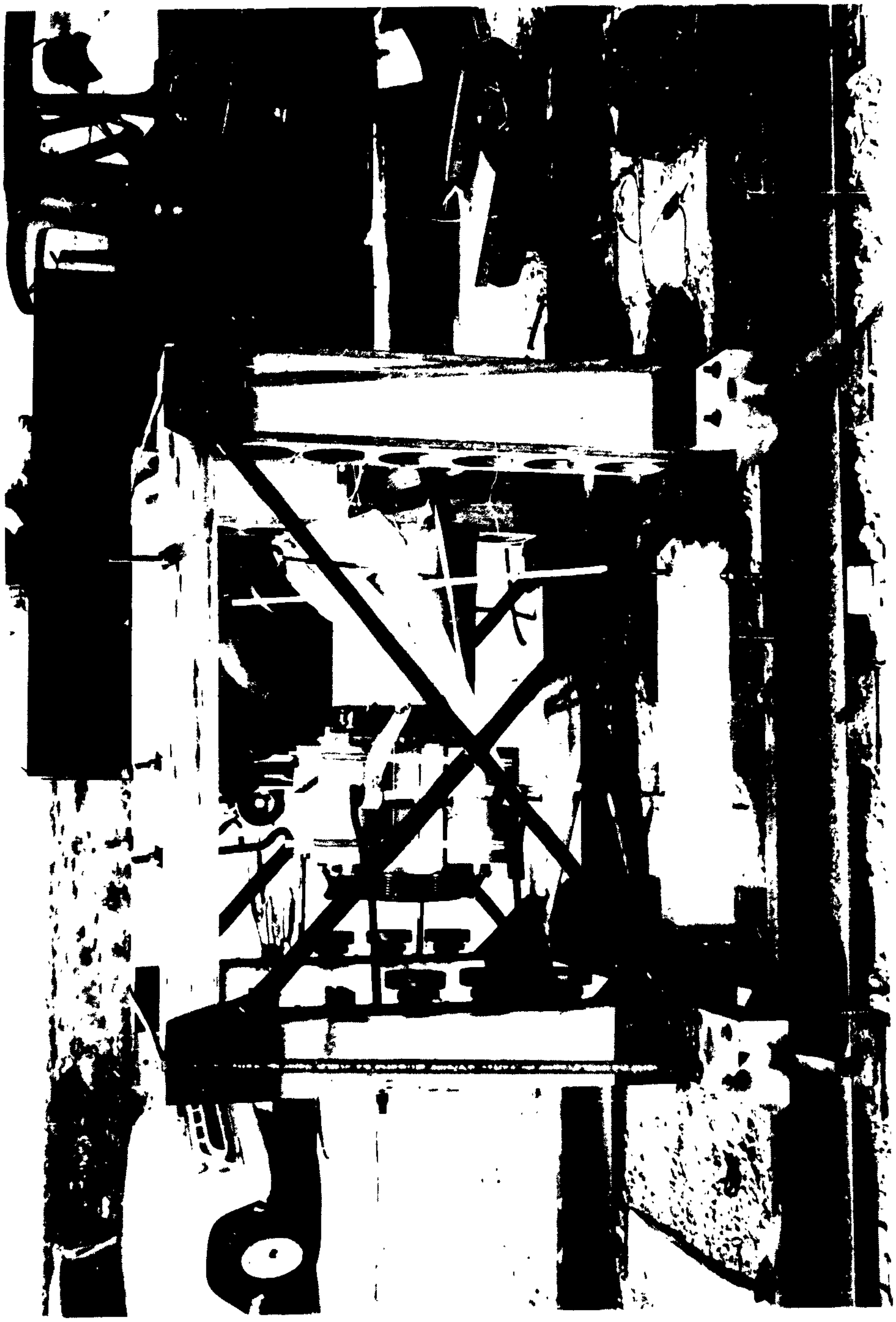

Figure 32. Sled-mounted test item -- third water impact test

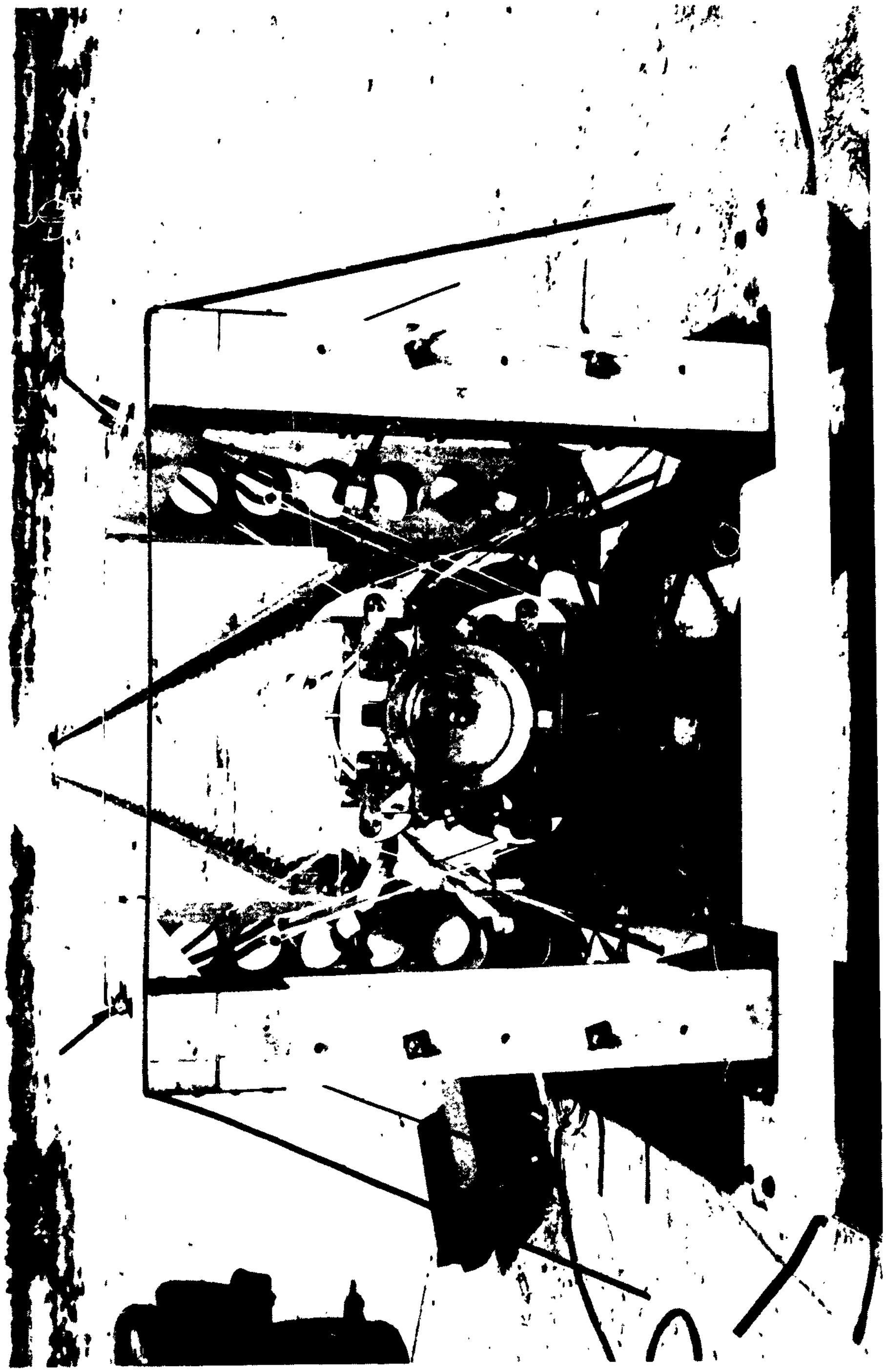

Figure 33. Sled-mounted test item -- third water impact test

Figure 34. Frangible water tank -- post test

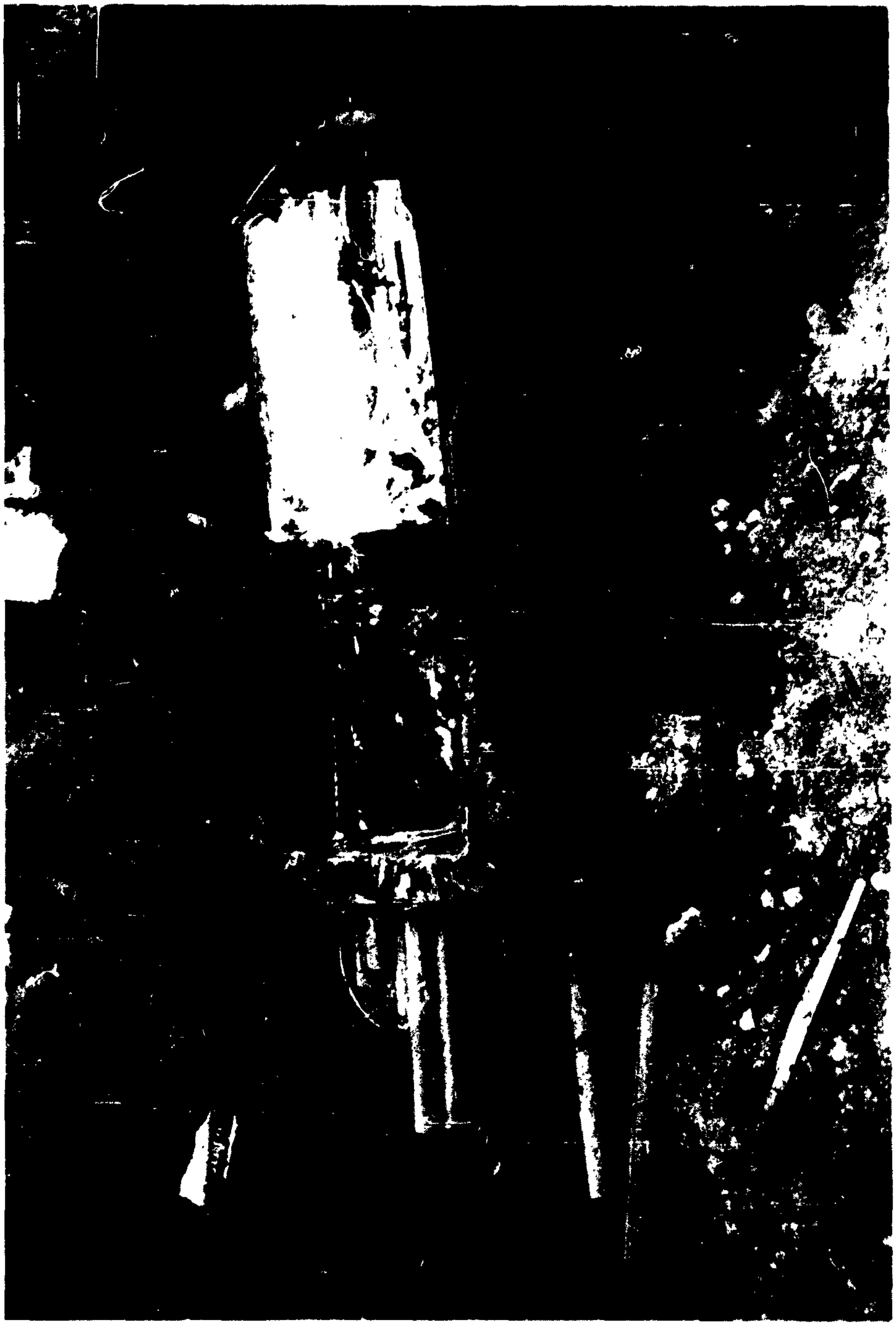

Figure 35. Reactor vessel -- post test

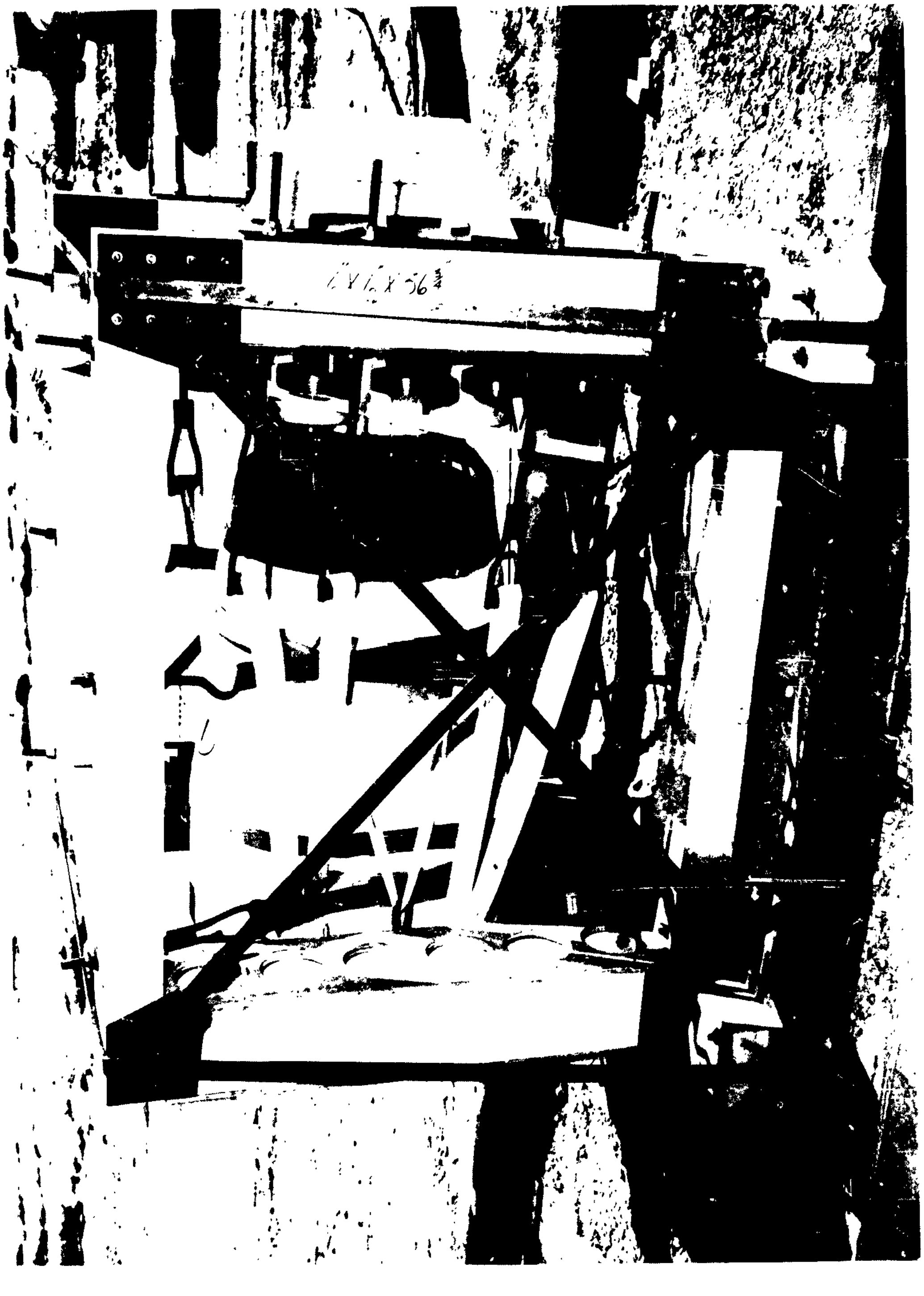

Figure 36. Sled-mounted test item -- fourth water impact test

Figure 37. Sled-mounted test item -- fourth water impact test

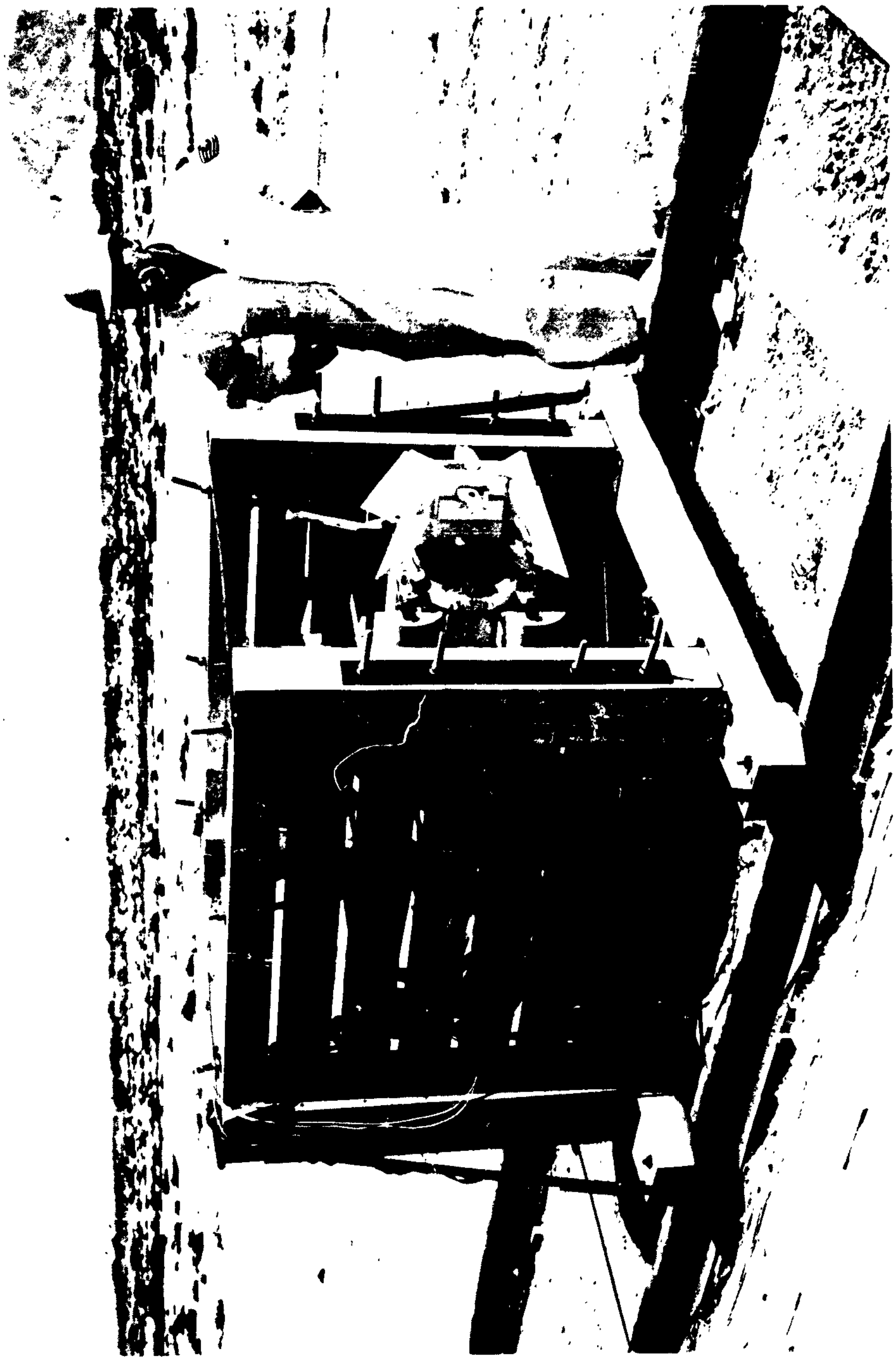

Figure 38. Booster-loaded sled — fourth water impact test

Figure 39. Frangible water tank — post test

Figure 40. Partial radiator - post test

Figure 41. Reactor vessel — post test

DISTRIBUTION

No. cys	
	HEADQUARTERS USAF
2	Hq USAF (AFRST-NE, Col O. P. Thorne), Wash 25, DC
	MAJOR AIR COMMANDS
2	AFSC (SCT), Andrews AFB, Wash 25, DC
1	AUL, Maxwell AFB, Ala
	AFSC ORGANIZATIONS
	RTD, Bolling AFB, Wash 25, DC
2	(RTT)
2	(RTO)
4	AF Msl Dev Cen (MDRGT-R, Capt D. C. Cole), Holloman AFB, N Mex
	KIRTLAND AFB ORGANIZATIONS
	AFSWC, Kirtland AFB, N Mex
1	(SWEH)
50	(SWOI)
25	(SWV)
	OTHER DOD ACTIVITIES
10	ASTIA (TIPDR), Arlington Hall Sta, Arlington 12, Va
	AEC ACTIVITIES
	US Atomic Energy Commission, Wash 25, DC
5	(DRD, Dr. J. Lieberman)
5	(Mr. Kirk)
2	US Atomic Energy Commission, Canoga Park Area Office, ATTN: Mr. Carl Malmstrom, P.O. Box 591, Canoga Park, Calif
2	US Atomic Energy Commission, (ALO, Mr. E. C. Stewart), Sandia Base, N Mex
2	Sandia Corporation, ATTN: Mr. A. T. Clark/7112, Sandia Base, N Mex

DISTRIBUTION (cont'd)

No. cys	
	OTHER
4	Atomics International, ATTN: Mr. R. L. Detterman, P.O. Box 309, Canoga Park, Calif
1	National Aeronautics and Space Administration, ATTN: Mr. Thomas B. Kerr (RNS), 1512 H Street, NW, Wash 25, DC
1	Official Record Copy (SWVPS, Lt John Belson)

Air Force Special Weapons Center, Kirtland AF Base, New Mexico
Rpt. No. AFSWC-TDR-62-144. SNAP 2/10A GROUND TEST PROGRAM, PHASE I. March 1963. 86 p. incl illus.

Unclassified Report

The purpose of the SNAP 2/10A Reactor Ground Test Program was to determine the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive, and impact environments.
Test engineering, data acquisition, and the preliminary test results are discussed. Atomics International will perform the final engineering analysis of the test data under USAEC contract.

1. Blast damage
2. Fire damage
3. Impact testing
4. SNAP -- testing
5. Safety hazards
6. Test equipment
7. Vulnerability studies

I. AFSC Project 1831, Task 071
II. John D. Belson, Lt USAF
III. In ASTIA collection

Air Force Special Weapons Center, Kirtland AF Base, New Mexico
Rpt. No. AFSWC-TDR-62-144. SNAP 2/10A GROUND TEST PROGRAM, PHASE I. March 1963. 86 p. incl illus.

Unclassified Report

The purpose of the SNAP 2/10A Reactor Ground Test Program was to determine the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive, and impact environments.
Test engineering, data acquisition, and the preliminary test results are discussed. Atomics International will perform the final engineering analysis of the test data under USAEC contract.

1. Blast damage
2. Fire damage
3. Impact testing
4. SNAP -- testing
5. Safety hazards
6. Test equipment
7. Vulnerability studies

I. AFSC Project 1831, Task 071
II. John D. Belson, Lt USAF
III. In ASTIA collection

Air Force Special Weapons Center, Kirtland AF Base, New Mexico
Rpt. No. AFSWC-TDR-62-144. SNAP 2/10A GROUND TEST PROGRAM, PHASE I. March 1963. 86 p. incl illus.

Unclassified Report

The purpose of the SNAP 2/10A Reactor Ground Test Program was to determine the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive, and impact environments.
Test engineering, data acquisition, and the preliminary test results are discussed. Atomics International will perform the final engineering analysis of the test data under USAEC contract.

1. Blast damage
2. Fire damage
3. Impact testing
4. SNAP -- testing
5. Safety hazards
6. Test equipment
7. Vulnerability studies

I. AFSC Project 1831, Task 071
II. John D. Belson, Lt USAF
III. In ASTIA collection

Air Force Special Weapons Center, Kirtland AF Base, New Mexico
Rpt. No. AFSWC-TDR-62-144. SNAP 2/10A GROUND TEST PROGRAM, PHASE I. March 1963. 86 p. incl illus.

Unclassified Report

The purpose of the SNAP 2/10A Reactor Ground Test Program was to determine the structural behavior of the SNAP 2/10A reactor assemblies when subjected to thermochemical, fire, explosive, and impact environments.
Test engineering, data acquisition, and the preliminary test results are discussed. Atomics International will perform the final engineering analysis of the test data under USAEC contract.

1. Blast damage
2. Fire damage
3. Impact testing
4. SNAP -- testing
5. Safety hazards
6. Test equipment
7. Vulnerability studies

I. AFSC Project 1831, Task 071
II. John D. Belson, Lt USAF
III. In ASTIA collection